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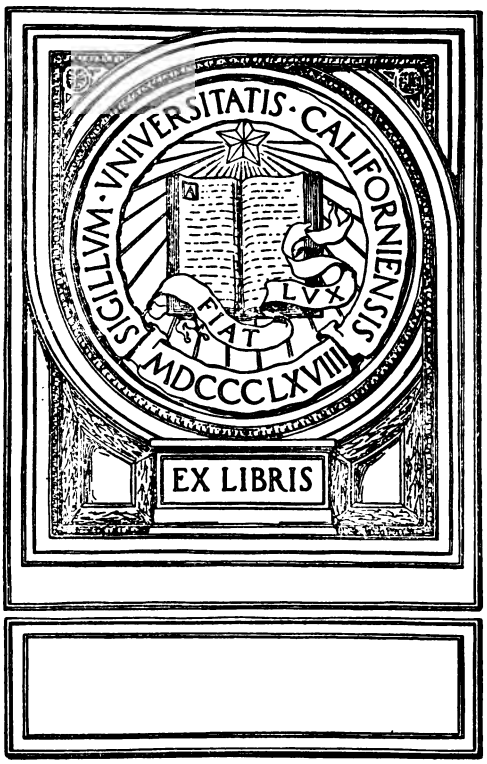
CLASSIFICATON AND USES OF FINGER PRINTS

E. R. HENRY C.S.I.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CLASSIFICATION AND USES

OF

FINGER PRINTS

BY

E. R. HENRY, C.S.I.
(INDIAN CIVIL SERVICE)

UNIV. OF
CALIFORNIA

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PREFACE

THE employment of finger prints in many branches of public business, as a check upon false personation, having necessitated the use of a book of reference, this volume has been prepared by order of the Government of India.

It is divided into two Parts, over two hundred diagrams being provided to illustrate the letter-press. Inset headings to paragraphs, and the Index, will, it is hoped, facilitate search for information.

Part I. contains the definitions by means of which any finger impression may be accurately described, and explains, when two prints are brought under examination, the numerous points in each that should be compared with a view to establishing identity or dissimilarity. This Part will be useful to Departments such as Registration, Pensions, Post Office, Survey, Opium, and others who take the impression of a single digit.

Part II. contains an account of the system of classification, the full scheme of which is set forth in

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the Synopsis (Plate 5). This Part will be required by the Police Department.

Endeavour has been made to compress the letterpress into the smallest space compatible with clearness and completeness of description.

1st June 1900.

PART I

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FINGER PRINTS

PART I

Earlier inquiries into the subject.—The employment during past times of finger prints among various nations is discussed in the writings of Mr. Francis Galton, who finds the significance attached to their use to have been partly superstitious and partly ceremonial. As bearing upon this point he refers to the modern witness who, when sworn on the Bible, is made to hold it and kiss it, and to the executant of a document who touches a wafer or seal and declares "this to be my act and deed." In 1823, Purkenje, a Professor of Physiology and Pathology, read before the University of Breslau a Latin Thesis on finger impressions, in which he gives nine standard types, and suggests a system of classification, but his labours failed to attract the attention they merited. Bewick, the reviver of wood-printing in England, appears to have been struck with the delicacy of the lineations, for he made engravings on wood of a couple of his fingers, which he used as designs for his illustrated

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works. Mr. Galton also tells us that when the immigration of the Chinese was causing so much excitement in America the suggestion was made, but not acted on, that a system of finger-printing might be used for their registration. But no departure at any time previously made is comparable in importance with the systematised labours in this direction of Sir William Herschel, of the Indian Civil Service. Finding false personation prevalent in all the Courts, he determined to introduce the use of finger impressions in the district of Hooghly, in Bengal, of which he was then in executive charge, as a means of fixing identity, and accordingly insisted upon executants of documents admitted to registration affixing their finger impression in the Register of Admissions. He submitted a report to the Government advocating the adoption of this system throughout the Province; but the subject had not then been sufficiently popularised, and his recommendation met the fate of many other good suggestions and was not acted upon, and after his departure the check he had introduced was abandoned.

His labours have not, however, been unfruitful, for he collected many of the materials without which Mr. Galton, who commenced his investigation of the subject about ten years ago, would not have been able to fix so securely the foundations of this new branch of inquiry. In addition to providing types and a nomenclature, suggesting a system of classification and examining the character and purpose of the ridges in their physiological

aspect, Mr. Galton has discussed the all-important question of Persistence, and has proved that the details of the ridges constituting the patterns of finger impressions persist throughout the whole period representing the life of man, those found on the fingers of the new-born infant being traceable on the fingers of the same person in old age and apparently effaceable only when after death decomposition sets in. In dealing with the subject anthropologically, he has brought together some evidence to indicate the transmissibility of patterns by descent, but finds that no sensible amount of correlation exists between the patterns of impressions and the bodily faculties or characteristics, or that these finger markings are distinctive of race or temperament. In the system here described, many of his terms have been adopted, his definitions accepted, and his suggestions followed whenever practicable. As will be explained, it has been found desirable to increase the number of type patterns, and to fix them by definition with a view to eliminating as much as possible transitional cases, and a system of classifying not dependent upon the employment of suffixes has been adopted. But these are details which can be more conveniently treated later on, and are only noticed now when referring to the great value and to the extent of Mr. Galton's inquiries into the subject.[1]

Finger prints utilised in many branches of

[1] "Finger Prints and the Detection of Crime in India," a paper read before the British Association Meeting, Dover, 1899.

public business.—The employment of the new system has not been restricted to the Police Department, but has been introduced into all branches of public business, being particularly well suited to the requirements of a country where the mass of the people are uneducated, and where false personation is an evil which even the penalties provided by the penal laws are powerless to control. It is believed that, on the death of pensioners, friends or relations have personated them and have continued to draw allowances which should have lapsed with the death of the persons to whom they were originally granted. All military and all civil pensioners are now required to give their finger impressions, and this precaution is effective against fraud. The Courts have to deal with numerous contested cases in which transfers of proprietary or other rights, purporting to have been duly admitted in the presence of witnesses before a registrar of deeds, are repudiated, and evidence is adduced on either side, often of the most conflicting and indecisive nature, both parties not hesitating to rely upon suborned testimony. In all registration offices in the Province of Bengal, persons who, admitting execution, present documents for registration, are required to authenticate their signature or mark by affixing the impression of their left thumb both on the document and in a register kept for the purpose. Should an executant repudiate as not genuine a deed which purports to be a transfer by him of certain rights, the judicial officer can require the person repudiating to give

his thumb impression in open Court, and this is compared with the impression on the document and in the register, and can be proved to be either the same or a different impression, and this settles the point at issue. In this way, during the last three years, several cases of false personation have been detected and prosecuted to conviction, and the deterrent effect has been so marked as to justify the belief that the volume of work which the Courts have to cope with will be sensibly reduced in amount.

In the Opium Department large advances are made on account to the cultivators through middlemen, the poppy crop being hypothecated as security. If the middleman or cultivator proves dishonest, the issue is raised whether particular sums reached the persons they were intended for. Formerly the cultivator could disown his mark or signature, or the middleman could put forward as the cultivator's mark or signature one that had been fraudulently made; but as the finger impression of the payee is now required to authenticate acknowledgment of receipt, a check has been introduced, the efficacy of which both cultivators and middlemen fully appreciate. The employer who makes advances to labourers, or pays them salaries, or enters into contracts with them, now protects himself by taking their finger prints on the receipt or agreement. All emigrants signing contracts under the Emigration Act are required to give the impression of their left thumb on the contract and on the registers. With large establishments, such as are employed by the Survey of India, this system is

used to prevent the re-employment of undesirable persons whose services have been dispensed with. The thumb impressions of the employees are taken and registered, and if a particular man is dismissed for misbehaviour, a photo-zincograph of his impression is sent to all the working parties, which ensures that he cannot again get taken on, even by assuming a false name.

Since April 1899 the system has been adopted by the Director-General of the Post Offices of India, and has been made applicable to all present and future non-gazetted officers, who number many thousands. In the Medical Department of the Bengal Presidency, the local medical officer and the Medical Board, when giving certificates, invariably take the thumb impression of the person examined. There is believed to be much false personation at public examinations in India, the candidate who appears in the Examination Hall not being the person who secured the certificate entitling him to compete. In examinations for employment in one branch of Government service this check has been introduced, and is working excellently, and it will no doubt be extended. In connection with the administration of the rules for preventing the spread of plague, and for regulating the pilgrimage of Mussulmans to Mecca, certificates are authenticated by bearing the thumb impression of the persons to whom they are granted.

It would be tedious to enumerate at greater length the many uses to which the system is being put, though as yet its value to insurance offices

has not been realised, the difficulty, probably, being that, owing to the circumstances of the country, bodies are buried or burnt almost as soon as death occurs. There is no doubt that the impression of the finger of a dead person taken before decomposition sets in would fix his identity in a most convincing way if the deceased had at any previous time been required to give the impression of the same finger. Its value as a means of authenticating testamentary dispositions cannot be overestimated.

It must be recognised that the introduction of finger impressions in proof or disproof of identity where the person in question is known and accessible, and has given his mark on a previous occasion, is an extraordinarily efficient method of preventing perjury and personation. No objection can be raised on the ground of religion or caste, or rank in society, or sex, so there is no prejudice to be overcome in obtaining it. The Government has been so fully convinced of the effectiveness of this new system, and of the certainty of the results it yields, that within the last few months the Indian Legislature has passed a special Act[1] amending the Law of Evidence to the extent of declaring relevant the testimony of those who by study have become proficient in finger-print decipherment, such testimony not having been admissible under the unamended law.[2]

[1] Act V. of 1899 (India Council).

[2] "Finger Prints and the Detection of Crime in India," a paper read before the British Association Meeting, Dover, 1899.

Ridges—Creases; their origin; purpose they serve.—The inner part of the hand and the sole of the foot are traversed in all directions by lines of varying lengths, some representing depressions, others elevations of the skin surface, many of them being grouped into patterns which, though seemingly complex, can be outlined with exactness. The most conspicuous are the creases, caused by the folding of the skin. These are found well developed in the newly-born child, and can be rendered more apparent by partially closing the hand. So far as is known at present they fulfil no particular office, being nothing more than the lines of flexure of the skin, and are of interest only to students of palmistry. The less conspicuous but much more numerous lines are the papillary ridges which appear over the whole surface, giving to it an appearance that may be likened to that of a newly ploughed field with its ridges and furrows, or to sand which the water in receding from has left ribbed. There is no connection between the two classes of marks, the directions of the creases not determining the course of the ridges, and their embryological development being distinct. The ridges are studded with microscopic pores, the mouths of the ducts of the glands which secrete perspiration located below the epidermis. Physiologists are not agreed as to the uses of these ridges, or as to how they have been formed. It has been conjectured that their office is to raise the mouths of the ducts so as to facilitate the discharge of the sweat and also possibly to assist in some undefined way the sense of touch. In very young children the

delicacy of the ridges corresponds with the development of the child. They grow with the growth of the body, and are most marked in hands that do some work, though liable to lose their sharpness of definition and even to become obliterated on those parts of the hands where from continued pressure callosities form. This may be noticed in labourers and artisans whose hands have become hardened by the use of the tools or other implements of their trades. Injuries do not, necessarily, obliterate the ridges. An ulcerated sore eating so deeply into the flesh as to destroy the sweat glands would certainly destroy the ridges, and from the surface of a lasting scar the ridges disappear. A cut leaves across the ridges a permanent thin mark which, when the impression is taken on paper, shows as a white space somewhat similar to a crease.

In addition to the creases which are permanent, such as those marking the divisions between the phalanges of the fingers and those on the palm caused by the doubling up of the hand, creases not permanent may appear on the bulbs of the fingers, which might not again show themselves in a duplicate impression taken after a lapse of time. It is specially needful, therefore, not to place undue reliance upon these creases when impressions are brought under examination in order to establish identity or dissimilarity. The occurrence in two impressions of obviously the same crease is a great aid to the eye, but two impressions of the same finger may be taken, —the second with a well-defined crease, caused by pressing the bulb surface with the blade of a knife or

the edge of a steel pen, while the first is creaseless. An unskilful person missing the crease in one impression might be misled and fail to realise that the two impressions before him are identical. It cannot be too often reiterated that in comparing impressions the examiner must rely upon similarity or dissimilarity in the type and in the details of the ridges of the patterns: if his conclusions deduced therefrom are further corroborated by coinciding creases, so much the easier his task. Creases will be found in Illustrations 2, 10, 22, 23, 43, 53, 57, 62, 70, and others. They must not be confused with cicatrised cuts (Fig. 11, and Illustrations 9 and 13); in the latter there is, it will be noticed, some displacement and puckering of the divided ridges.

Persistence throughout period of human life of pattern and ridge characteristics.—Impressions being required for permanent record, their utility must, in great measure, be contingent upon the persistence through long periods of time of the general form of the pattern and of the details of the ridges constituting it.

Mr. Galton has investigated this point, and in the following words records the results of his examination of many sets of prints taken at different times, and covering the interval from childhood to boyhood, from boyhood to early manhood, from early manhood to middle age, and from middle to extreme old age: "As there is no sign, except in one case, of change during any of these four intervals which together almost wholly cover the ordinary life of man, we are

justified in inferring that between birth and death there is absolutely no change in say 699 out of 700 of the numerous characteristics of the markings of the fingers of the same person such as can be impressed by him wherever it is desirable to do so. Neither can there be any change after death up to the time when the skin perishes through decomposition: for example, the marks on the fingers of many Egyptian mummies and on the paws of stuffed monkeys still remain legible. Very good evidence and careful inquiry is thus seen to justify the popular idea of the persistence of finger markings. There appear to be no bodily characteristics other than deep scars and tattoo marks comparable in their persistence to these markings; at the same time they are out of all proportion more numerous than any other measurable features. The dimensions of the limbs and body alter in the course of growth and decay; the colour, quantity, and quality of the hair, the tint and quality of the skin, the number and set of the teeth, the expression of the features, the gestures, the handwriting, even the eye colour, change after many years. There seems no persistence in the visible parts of the body except in these minute and hitherto disregarded ridges." In speaking of the persistence of the marks on the fingers, the phrase must be taken to apply to the details of the ridges and to the general character of the pattern; not to the measure of its length, breadth, or other diameter, these being no more constant than the stature or any other of the ordinary anthropometric data.

Appliances used.—The appliances required are few and inexpensive. Ordinary white paper with the surface not too highly glazed, some printer's ink and a roller for spreading it, consisting of a wooden cylinder 2 inches long, half an inch diameter, over which a piece of rubber tubing has been tightly stretched; at either end of the cylinder brass pins are driven in to form the axle on which the handle works. A piece of flat tin. A pointer, which can be made of a penholder handle, with a needle or sharp-pointed brass wire let in at one end. This pointer is used for ridge counting and ridge tracing. Persons with very good sight are able to dispense with optical aid, but a reading glass such as is used for looking at photographs or reading small print is more or less indispensable, and should always be kept available; for blurred prints a common pocket lens is required. All these articles can be procured through any stationer. A word of caution may be added. The ink, roller, and slab must be kept scrupulously clean and free from dust, grit, and hairs. The ink should be kept in a bottle or other receptacle that can be hermetically closed. The roller when not in use may be kept wrapped up in a piece of clean oiled paper. The slab should be freshly cleaned each day, all particles of old ink being rubbed off.

"Plain," "rolled" impressions—How taken.—Impressions are taken in two ways, as "plain" and as "rolled" impressions. Fig. 1 is an example of the "plain," Fig. 2 of the "rolled" impression of the same thumb. (By "rolled" here is meant

the cylindrical projection of the pattern upon paper.)

To take a "rolled" impression, the bulb of the finger is placed upon a tin slab over which a thin film of printer's ink has been spread, the plane of the nail being at right angles to the plane of the slab, and the finger is then turned over until the bulb surface, which originally faced to the left, now

FIG. 1.

FIG. 2.

faces to the right, the plane of the nail being again at right angles to the slab. By this means the ridge surface of the finger between the nail boundaries is inked, and, by pressing it lightly upon paper in the same way that it was pressed upon the inked slab, a clear rolled impression of the finger surface is obtained. Care must be taken not to press the finger too heavily on the inked slab or subsequently too heavily on the paper, otherwise a blurred or

imperfect impression results. To obtain good impressions, the following details must receive attention. The tin slab in use should be free from dust, hairs, or other foreign matter. It should be freshly cleaned each day, all traces of the ink previously used being removed. A very small quantity of ink should be applied, and this should be worked up into the thinnest possible film: unless the film is thin, the impression obtained will not be clear and sharply defined. From a finger so inked a good impression is secured, as even additional pressure will not do much harm. The paper used should be white and its surface not too glazed, for, unless it is sufficiently absorbent, nearly all the ink will remain on the finger, less adhering to the paper, the print resulting not being in consequence sufficiently dark. Good impressions can be taken on ordinary foolscap. Stress is laid upon the paper being white, so as to facilitate the work of photographing, should a photograph of the impression be, at any future time, required. Many kinds of ink have been experimented with, but, on the whole, printer's ink is the most satisfactory, as it is procurable everywhere at trifling cost. The paper being porous absorbs the ink impressed on it by the finger, and, as the principal constituent of this ink is oily matter which readily oxidises under the action of the air, the sheets containing impressions may be at once handled without risk of defacement from smudging. The slab can be made of sheet copper or any other metal; but as tin is the cheapest and most easily procured, it has been generally adopted.

A "plain" impression is obtained by placing the bulb of the finger on the inked slab and then impressing it on paper without any turning movement.

Reasons for taking "rolled" prints.—Though both operations present no difficulty, taking a "plain" impression is the simpler of the two, and it may be well therefore to explain why a "rolled" impression is required. Referring to Figs. 1 and 2, which are impressions of the same thumb, it will be seen that in Fig. 1 the whole contour of the pattern does not appear, whereas in Fig. 2 the whole pattern is reproduced. Obviously therefore, for reasons hereafter given, it is easier to determine the type of pattern from a "rolled" impression; moreover, the greater surface of the latter enables a larger number of points for comparison to be selected when it is a question of contrasting the details of two prints with a view to deciding whether they are impressions of the same or of different digits.

All impressions divisible into four types.—Innumerable trials have been made with a view to fixing standards or types according to which all impressions can be readily sorted; Purkenje proposed nine, Mr. Galton three. As the outcome of much experimenting, a fourfold classification is recommended, as it meets all requirements while greatly reducing the number of gradational cases.

These four types are: Arches; Loops; Whorls; Composites.

Definitions are given on page 20 and following

pages; numerous diagrams and illustrations being utilised to make the definitions intelligible.

Fixed points in impressions.—In impressions of the Loop, Whorl, and Composite types there are fixed points which, as will hereafter appear, subserve several useful purposes. These fixed points are:

(1) The "delta" or "outer terminus."

(2) The "point of the core" or "inner terminus."

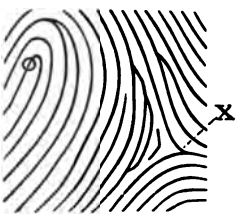


FIG. 3.

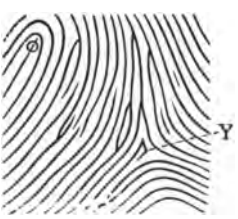


FIG. 4.

Delta; "Outer terminus."—The "delta" here referred to may be formed either (*a*) by the bifurcation of a single ridge, or (*b*) by the abrupt divergence of two ridges that hitherto had run side by side.

(*a*) Where the upper and lower sides of the "delta" are formed by the bifurcation of a single ridge, the point of bifurcation forms the "outer terminus," marked X in Fig. 3. Where there are several such bifurcations, the one nearest the core is taken as the "outer terminus."

(*b*) The upper and lower sides of the "delta" may be formed by the abrupt divergence of two ridges which, up to this point, had run side by side. The nearest ridge in front of the place where the divergence begins, even if it be a mere point, and

whether it is independent of or sprung from the diverging ridges or not, is the "outer terminus," marked Y in Fig. 4.

Core; Point of core; Inner terminus.—The core of a Loop may consist either of an even or an uneven number of ridges (termed "rods") not joined together thus:

FIG. 5.

or it may consist of two ridges formed together at their summit (termed "staple"), thus:

FIG. 6.

Where the core consists of an uneven number of rods, the top of the central rod is the "point of the core." If the core is a staple, the shoulder of the

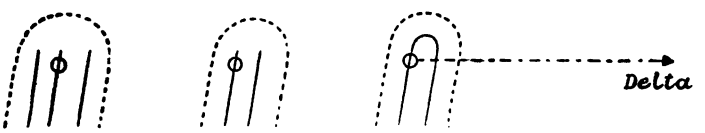


FIG. 7.

staple that is farthest from the delta is taken as the "point of the core," the nearer shoulder counting as

a separate ridge. Where the core consists of an even number of rods, the two central ones are considered as joined at their summits by an imaginary neck, and, of these two, the shoulder farthest from the delta is the "point of the core." In Whorls circular or elliptical in form, the centre of the first ring is the "point of the core." Where the Whorl is spiral in form, the point from which the spiral begins to revolve is the "point of the core." "Point of the core" is synonymous with "inner terminus."

In the above diagrams the first ridge that envelopes the core is dotted.

Illustrations 149 to 164 inclusive have the "inner terminus" (I. T.) and "outer terminus" (O. T.) drawn under each impression. Study of these illustrations will, it is hoped, make the definitions quite intelligible. As explained under *ridge counting*, Loops are differentiated according to the number of ridges which intervene between their "inner" and "outer terminus," these *two terminal points being excluded from the count.*

Arches.—In Arches the ridges run from one side to the other, making no backward turn; there is ordinarily no delta, but, when there is the appearance of a delta, *no ridge must intervene between the "inner" and "outer terminus."* Figs. 8 and 9 present no difficulty.

In Figs. 10 and 11 there is, in each, one ridge which has the appearance of recurving, and it might be contended that these impressions are of the type of both the Loop and the Arch; but when the above

FIG. 8.

FIG. 9.

FIG. 10.

FIG. 11.

definition is applied, it will be seen that as no ridge comes into count between the two terminal points, they fall within the class of Arches.

The impressions given in Illustrations 1 to 12 inclusive are Arches. In Illustrations 13, 14, 15 one ridge, in Illustration 16 two ridges intervene between the terminal points: these impressions therefore are Loops and not Arches.

FIG. 13.

Tented Arches.—In patterns of the Arch type, the ridges near the middle may have an upward thrust, arranging themselves as it were on both sides of a spine or axis, towards which adjoining ridges converge. The ridges thus converging give to the pattern the appearance of a tent in outline, hence the name Tented Arch (Fig. 13). In order to demarcate clearly the line which separates Tented

Arches from those Loops whose ridges have a more or less vertical trend, it is held that, if *on either side of the axis even one ridge recurves*, the impression is a Loop (Fig. 12). The meeting of two ridges at a sharp angle resulting from their running into each other through not maintaining their parallelism of direction, is not to be confused with recurving. The recurving ridge must be wholly on one side of

FIG. 12.

the axis. Illustrations 17 to 24 inclusive are Tented Arches. Illustration 25 has one recurving ridge to the right of the axis; Illustration 26 has one to the left (some converging ridges may be noticed in this impression); Illustration 27 has two recurving ridges at least, to the right of the axis, so these impressions 25, 26, and 27 would be classed as Loops.

Loops.—In Loops some of the ridges make a backward turn but without twist; there is one delta (Figs. 14, 15).

In Fig. 15 the ridge, or, if it be likened to water, the stream A X bifurcates into X C and X D. X C at first follows an upward course, and, having reached its greatest height, trends downwards, passing away to the left side, while X D proceeds generally in the direction followed by A X; there is one delta, namely, at X. The trend of the ridges about the core, *i.e.* the direction from their summit to their exit between C D, is a slope from the right of the person looking at them towards his left.

In Fig. 16 some of the core ridges meet an enveloping ridge at an acute angle; compare Illustrations 44, 45, 46, 47, 48, 49. In Fig. 17 the summits of the ridges are deflected slightly downwards; compare Illustrations 35 and 36.

The Illustrations 28 to 49 inclusive exhibit many varieties of Loops, and may be studied with advantage.

Ulnar and Radial.—When seen in a looking-glass, the right hand appears as a left hand, the right eye as a left eye, the right half of the body as a left half. Similarly, the print of a finger is a reversal of the pattern on the finger; if this pattern on the finger be a Loop with slope from left to right, it will appear in the print as a Loop with slope from right to left. If a finger print impressed on transparent paper be held in front of two persons facing each

FIG. 14.

FIG. 15.

FIG. 16.

FIG. 17.

other, the pattern as seen by the one will be a reversal of the pattern as seen by the other; all the details of the print will of course correspond, but to the one observer the ridges which lie to the left of a central line will to the other observer appear to lie to the right. This is precisely what occurs when the same pattern exists on corresponding fingers of the two hands, as may be seen by taking prints from the two fingers, when it will be observed that one print delineates a pattern which is a reversal of the pattern delineated by the other. This has to be borne in mind in determining whether a Loop is *ulnar* or *radial.* A Loop is *ulnar* = U when the downward slope of the ridges about the core is from the direction of the thumb towards that of the little finger. It is *radial* = R when the downward slope is from the direction of the little finger towards the thumb.

The following rule may always be usefully applied. When the print under examination is that of a right hand digit, place the right palm on the table; if the downward slope of the ridges about the core is from the thumb side towards the little finger the Loop is *ulnar*, if the slope is from the direction of the little finger towards that of the thumb it is *radial.* If the print is that of a left hand digit, place the left palm on the table, and apply the rule. Using the symbol \ for *ulnar* and / for *radial* in the right hand, these symbols will be reversed for the left hand, where / = *ulnar* and \ = *radial.*

If the impressions of Figs. 14 and 15 are those of

a left hand digit, they are *ulnar* Loops; if of a right hand, they are *radial.* Referring to the Illustrations, if they are impressions of a right hand digit, 31, 32, 35, 37, 42, 46 are *ulnar* Loops, 30, 33, 34, 38, 39, 40 being *radials.* If they are impressions of a left hand, 31, 32, 35, 37, 42, 46 would be *radial,* and 30, 33, 34, 38, 39, 40 would be *ulnar.*

As it is essential to have this differentiation well understood, the point is dwelt upon. The terms *ulnar* and *radial* are borrowed from anatomy, the ulna and radius being the two bones of the forearm.

Whorls.—In Whorls some of the ridges make a turn through at least one complete circuit; there are two deltas. Whorls are single cored or double cored (Figs. 18, 19, 20, 21, 22, 23).

In Fig. 18 the ridge or stream A Y bifurcates at Y, the stream Y B making an upward turn before descending, while the stream Y C passes away towards the right side, this bifurcation causing the appearance of a delta at Y. On the right side of this same diagram the stream D Z, which flows from right to left, bifurcates at Z, causing the appearance of the delta there; the stream Z E at first flows upwards before taking a downward course, while the stream Z E, continuing in the direction of the parent stream D Z, passes away to the left.

In Fig. 20 the ridges about the core are elliptical in form. Fig. 21 exhibits a single spiral Whorl, Fig. 22 a double spiral. Fig. 23 is that of an impression which, for want of a better term, may

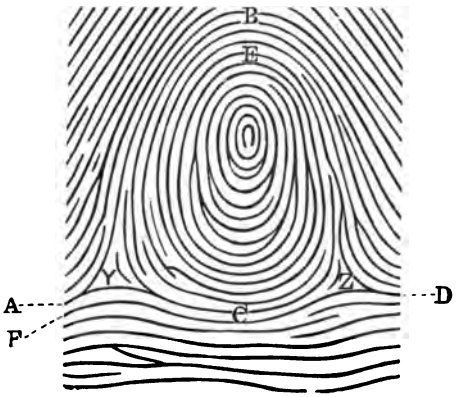


FIG. 18.

FIG. 19.

FIG. 20.

FIG. 21.

FIG. 22.

FIG. 23.

be called almond-shaped. In some patterns the spiral appears to revolve in the same direction as the hands of a watch, in others this revolution is in the opposite direction; great variety is noticeable in the cores; and very many details force themselves upon consideration when two impressions of this type are being compared.

Varieties of the Whorl type will be found delineated in Illustrations 101 to 124 inclusive.

Composites. — Under Composites are included patterns in which combinations of the Arch, Loop, Whorl are found in the same print, also impressions which might be deemed to present features requiring their definition as being Loops in respect of the majority of their ridges and Whorls in respect of a few ridges at the centre or side. These are subdivided into Central Pocket Loops, Lateral Pocket Loops, Twinned Loops, Accidentals.

Central Pocket Loops.—It not infrequently happens in patterns of the Loop type that the ridges immediately about the core deviate in course from the general course of the other ridges. Such impressions may therefore be said to possess features which require their being defined as Loops in respect of the majority of their ridges and Whorls in respect of the appearance of the few ridges which occupy a space immediately about the centre, a delta more or less faintly defined having in consequence made its appearance. Upon the analogy of a nomenclature adopted in mining, the space so occupied by ridges

whose course deviates from the course of the ridges surrounding them is described as a "pocket," and the impression as a Central Pocket Loop (Figs. 24 and 25).

All varieties of the Central Pocket type can be arranged under one or other of the forms of core shown in Fig. 26. These four standards overlap; II. is obviously only a modification of I., and III. a more complete form of IV. The arrow marks the position of the axis or line of exit of the ridges. Examining the standards, it will be noticed that this arrow if prolonged would meet at least one recurving ridge at right angles. This characteristic determines in doubtful cases whether an impression is a Loop or Central Pocket. These standards have been adopted to guide the eye, and because their employment often proves of assistance in at once deciding whether an impression is or is not a Central Pocket.

Illustrations 71, 72, 73, 74 come under Standard I.; in 75, 76, 77, 78 the axis meets ridges not at right angles but at an acute angle, and they moreover are converging not recurving ridges, so these impressions are excluded from Central Pockets and classed as Loops. Illustrations 79, 80, 81 come under Standard II. In Illustrations 82, 83, 84, 85 the ridge or ridges meet the axis at an acute angle; these impressions are classified as Loops. Standard III. possesses characteristics which can at once be noticed when they exist in an impression.

Standard IV. is the most comprehensive and most easily applied. The existence of even one

FIG. 24.

FIG. 25.

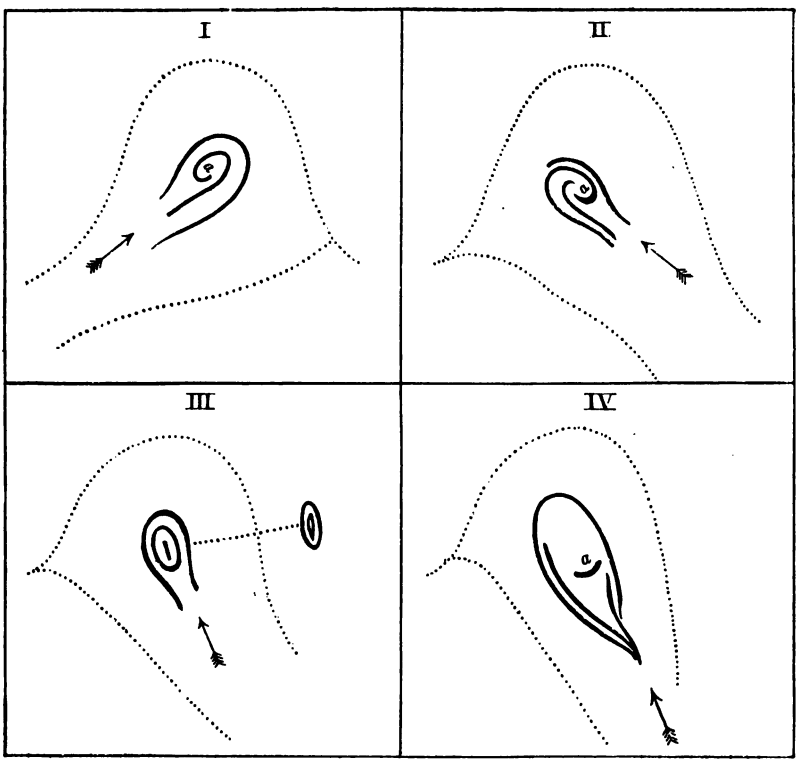


FIG. 26.

ridge whose course is at right angles to the axis brings the impression under this standard. Illustration 97 is a good example of this; 99 is a doubtful case, but, as figured, it falls according to the rule under Central Pockets. There will occasionally occur cases in which the application of the rule may appear doubtful, and these must be treated as transitional, and when search is made it must be made first on the assumption that the impression is a Loop, and then on the assumption that it is a Composite; but this will be more fully dealt with under Classification.

Lateral Pocket Loops.—When the ridges constituting the Loōp bend sharply downwards on one side before recurving, thereby forming on that side an interspace or "pocket," ordinarily filled by the ridges of another Loop, such impression is termed a Lateral Pocket Loop.

In Fig. 30A compare 1, 2, 4, 5; the outline of the Loop, whose ridges bend down sharply, is shown by the dotted lines, the thick dark line (*a*) represents its central ridge, the dark line (*b*) representing the central ridge of the Loop where ridges occupy the pocket. See also Figs. 27, 28, 29, 30, also Illustrations 50 to 57 inclusive. It should be realised that the ridges which bend downwards must be recurving not converging ridges — that their contour when they recurve must be rounded not angular. These ridges in Illustrations 58 to 65 inclusive converge, that is, they meet at an angle, and their contour in consequence is angular not rounded, hence the im-

FIG. 27.

FIG. 28.

FIG. 29.

FIG. 30.

LATERAL POCKET & TWINNED LOOP PATTERNS.

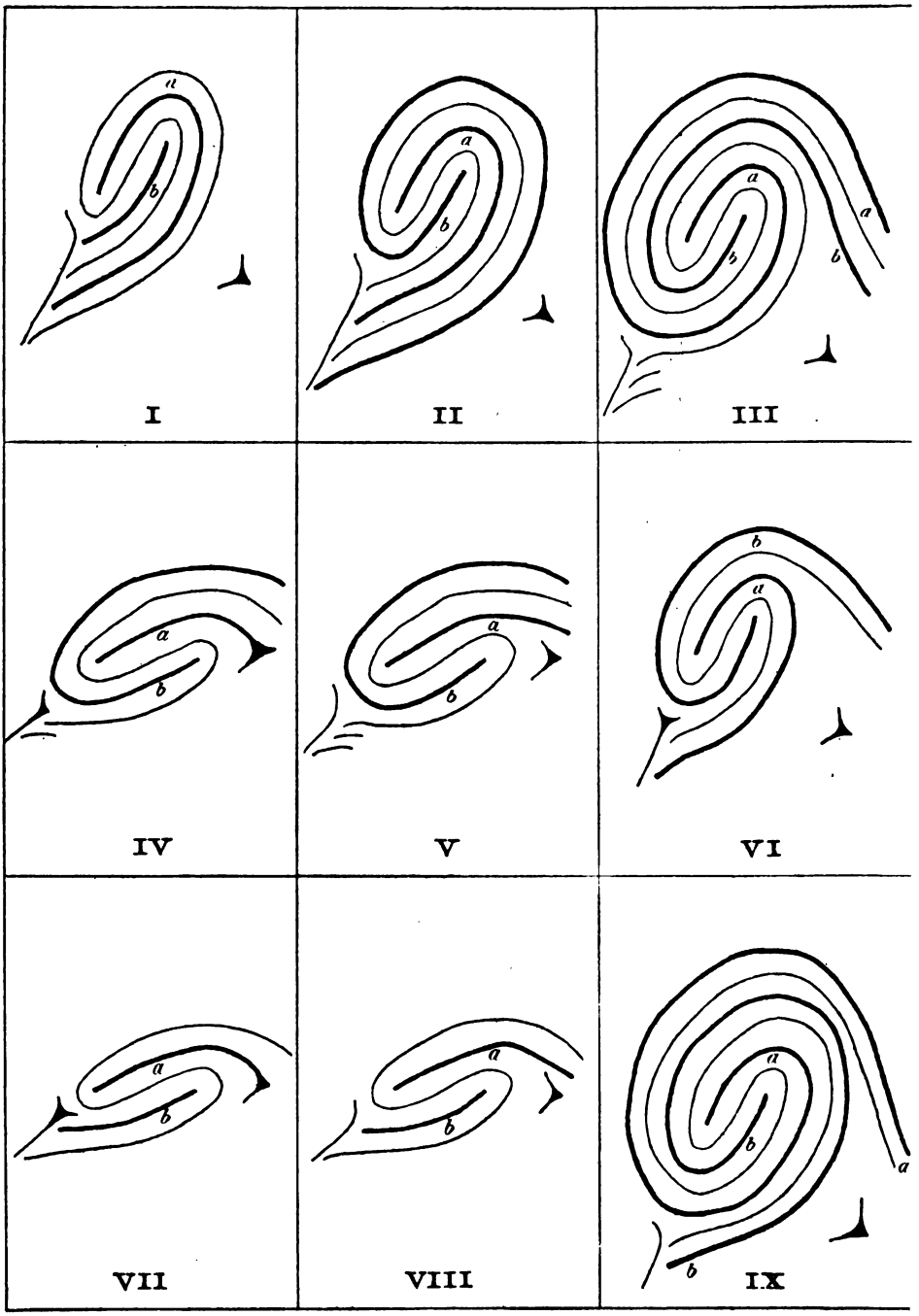


FIG. 30A.

FIG. 31.

FIG. 32.

pressions would be classified as Loops *ulnar* or *radial* and not as Lateral Pockets.

Twinned Loops and Lateral Pockets differentiated. — Referring to Figs. 31 and 32 and Illustrations 73, 74, 75, 76, 77, it will be seen that this at first sight complicated pattern in reality consists of two well-defined Loops, one superincumbent on or surrounding the other. Such an impression is termed a Twinned Loop.

Many Twinned Loops appear to be almost identical in contour and in details of ridge grouping with Lateral Pockets. Fig. 30A contains patterns which make clear the distinction which exists. The dark lines, marked *a*, *b*, are the central ridges of the two Loop systems, the ridges which contain the "points of the core." In 1, 2, 3, 4, 5, Fig. 30A, these ridges *a*, *b* have their exits on the same side of the right hand delta. In 6, 7, 8, 9 these ridges have their exits on different sides of the right hand delta. The following distinction therefore differentiates Lateral Pockets from Twinned Loops. In Lateral Pockets the ridges containing the "points of the core" *have their exits on the same side of the right delta*; in Twinned Loops the ridges containing the "points of the core" *have their exits on different sides of the right delta.* Both types of pattern are, as already stated, included under Composites, and further differentiation may appear unnecessary; but in practice it will be found very useful to have such a clear distinction between patterns which in general appearance closely resemble each other.

FIG. 33.

FIG. 34.

FIG. 35.

FIG. 36.

Accidentals. — Under Composites are also included the relatively small number of patterns too irregular in outline to be grouped under Central Pockets, Lateral Pockets, or Twinned Loops; they are termed, in the absence of a better nomenclature, Accidentals (Figs. 33, 34, 35, 36 and Illustrations 125 to 132 inclusive). Fig. 33 might be described as an Arch with Pocket. Fig. 34, at first sight, appears to be a Whorl surrounded by a Loop; Illustration 127 to be a Whorl resting on a Loop; 130 a Loop resting on a Whorl; but more strict examination shows that such descriptions lack accuracy, and it is better therefore to group these varieties into subclass Accidentals of class Composites.

Ridge counting.—As about two impressions out of every three are Loops, the subdivision into *ulnar* and *radial* fails to split them up into groups sufficiently small, and it is necessary therefore to still further differentiate them by other methods.

Fig. 37 represents the ridges of an ordinary Loop. The line S B joins the two terminal points, "inner" and "outer terminus." If the ridges which cut the line S B are *counted* they will be found to number 17, so this Loop is specialised as a Loop with 17 ridges or *counts*, and if it is the impression of a right hand digit it would be further specialised as an *ulnar*; if of a left hand digit as a *radial* Loop.

In ridge *counting* it must be remembered that the *two terminal points are excluded from count*, that ridges like G, which run close up to without

meeting the line S B, are also excluded, and that when two ridges result from a bifurcation as at D, close to the line S B, both are counted. A little practice will enable anyone with the help of a reading glass and a pointer to *count* ridges accurately and quickly.

Illustrations 149 to 164 inclusive may be studied; the "inner" and "outer terminus" are figured below

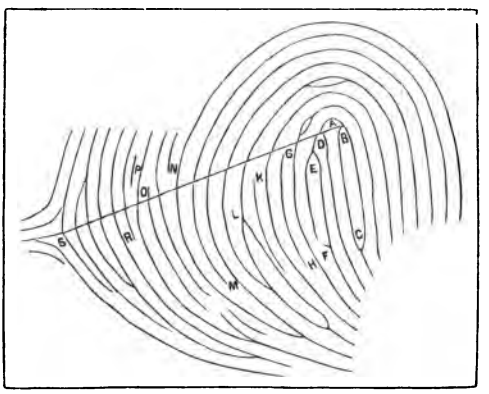


FIG. 37.

each impression, and the number of *counts* is given.

Ridge characteristics.—If Fig. 37 be again more closely examined, many other details of the ridges will be noticed. The "core" is a "staple" whose right limb bifurcates at B, and whose left limb bifurcates at D and again at E. In the ridge which immediately surrounds the core ridge is a small island to the left of D, and another in the third surrounding ridge directly above A. These islands come

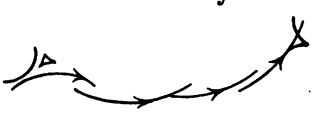
out clearly in the diagram, but in actual impressions they might appear as a bulging out or thickening of the ridge, due to the ink running. At G the ridge begins abruptly and ends abruptly at H, at K another ridge begins abruptly, at L another ridge bifurcates, at O another ridge begins abruptly. And there are many other similar details. These abrupt beginnings and endings, islands, bifurcations, etc., are known as ridge *characteristics.* Each marked departure from the general system of reticulation may be thus utilised.

Whorls and Composites present such innumerable varieties of pattern and of *characteristics* that when two Whorls are compared no difficulty is experienced in determining whether they are impressions of the same or of different fingers. But as it proves convenient to have them subdivisible into regular groups, the system employed may be described.

Ridge tracing.—In all impressions of the above two types there are two deltas, one to the left and the other to the right. These deltas are formed either by the bifurcation of a single ridge, or by the sudden divergence of two ridges that up to this point had run side by side. Taking the lower limb or lower ridge of these two, its course is followed, and it will be found either to meet to go inside or go outside the corresponding ridge of the right delta. When the ridge whose course is being *traced* stops short, the course of the ridge next below it is followed; when the ridge bifurcates, the *tracing* proceeds along the lower line of bifurcation. When the

ridge whose course is *traced* meets the corresponding right delta ridge the Whorl is specialised as M; when this ridge goes inside, it is specialised as I, when outside as O.

To secure an even distribution of I, M, O Whorls it has been found necessary to provide that if the ridge whose course is *traced* goes inside or outside the right delta ridge with not more than two ridges intervening between them, such ridge is considered as though it actually met the corresponding ridge. I therefore means that the left delta ridge goes inside the right delta ridge, there being between them not less than three intervening ridges; O means that the left delta ridge passes outside the right delta ridge, not less than three ridges intervening; and M means that the ridge whose course is *traced* actually meets the corresponding ridge, or that they are not apart by more than two intervening ridges. The definitions will be readily understood from the drawings below, where the ridge course *traced* is marked by the arrow head. See Illustrations 133 to 148.



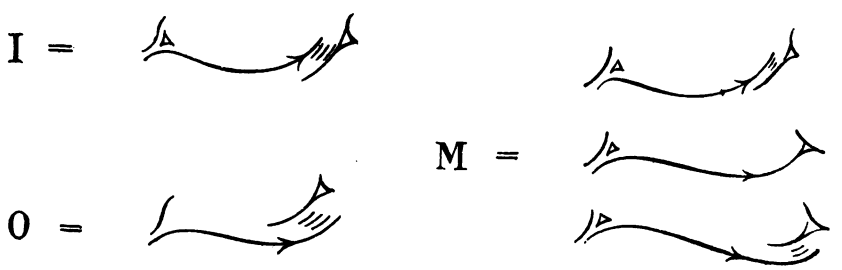


FIG. 38.

Summary of Preceding Paragraphs

What has been stated in preceding pages may now be briefly summarised. The palmar surface of the hand and the sole of the foot are traversed by innumerable ridges, forming many varieties of pattern, and by creases. The ridge patterns and the ridge *characteristics* persist throughout the whole period of human life, and are so distinctive as to differentiate each individual from all others. An accurate reproduction of these ridges is obtained by inking the finger bulb and pressing it on paper, the impression thus recorded being a reversal of the pattern on the finger. All impressions may be arranged under one of four types, namely, Arches, Loops, Whorls, Composites. Arches subdivide into Arches and Tented Arches; clear definitions demarcate Arches from Tented Arches, and both from Loops. Loops may be *ulnar* or *radial*, and are further differentiated from each other by ridge *counting* and by their ridge *characteristics*. Whorls are single or double cored; impressions of this type differ conspicuously from each other, owing to the innumerable varieties of pattern they present, but further demarcation is provided by ridge *tracing*. Composites include Central Pockets, Lateral Pockets, Twinned Loops, Accidentals; the definitions given are sufficient for the accurate differentiation of these subclasses.

In impressions there are fixed points known as "inner" and "outer terminus," whose correct position is readily found. These fixed points serve

many useful purposes, including ridge *counting*, ridge *tracing*, and the orientation of patterns.

Symbols used.—The symbols used are A = Arch; T = Tented Arch; L = Loop; W = Whorl; C = Composite; L P = Lateral Pocket; T L = Twinned Loop; C P = Central Pocket; Ac = Accidental; I T = "inner terminus"; O T = "outer terminus"; U = \ = *ulnar* in right hand; R = / = *radial* in right hand; U = / = *ulnar* in left hand; R = \ = *radial* in left hand.

Instance of practical use of system.—The facts of a notorious criminal case decided in the Bengal Courts in 1898, after a somewhat protracted inquiry, illustrate how the information afforded by finger prints may be utilised in practice.

"The manager of a tea garden situated in the district of Julpaiguri on the Bhutan frontier was found lying on his bed with his throat cut, his despatch box and safe having been rifled and several hundred rupees carried away. It was suggested that one of the coolies employed on the garden had committed the deed, as the deceased had the reputation of being a hard taskmaster, or that his cook, upon whose clothes were some blood spots, might be the culprit. There was suspicion also against the relatives of a woman with whom the murdered man had a *liaison*, also against a wandering gang of Kabulis of criminal propensities who had lately encamped in the neighbourhood. A representation was also made that the deceased had

an enemy in an ex-servant whom he had caused to be imprisoned for theft. Inquiry, however, satisfied the police that there was no evidence to incriminate the coolies or the relatives of the woman or the Kabulis, and it was ascertained that the ex-servant had been released from jail some weeks before, and no one could say that he had since been seen in the district. The cook's statement that the marks on his clothes were stains from a pigeon's blood which he had killed for his master's dinner was supported by the Chemical Analyst's report. Fortunately amongst the papers in the despatch box was found a calendar in book form, printed in the Bengali character, with an outside cover of light-blue paper on which were noticed two faint brown smudges. Under a magnifying glass one smudge was decipherable as a portion of the impression of one of the digits of some person's right hand. In the Central Office of the Bengal Police, the finger impressions of all persons convicted of certain offences are classified and registered, and the impression on the calendar when compared there was found to correspond exactly with the right thumb impression of Kangali Charan, the ex-servant above referred to. He, in consequence, was arrested in Birbhum, a district some hundreds of miles away, and brought to Calcutta, where his right thumb impression was again taken, and the police in the meantime set about collecting corroborative evidence. The Chemical Examiner to Government certified that the brown marks on the calendar were mammalian blood, the inference being that the actual murderer or some associate had knocked his blood-stained thumb against the calendar when rummaging amongst the papers in the despatch box for the key of the safe. The accused was committed to stand his trial before a

FIG. 39.

FIG. 40.

FIG. 41.

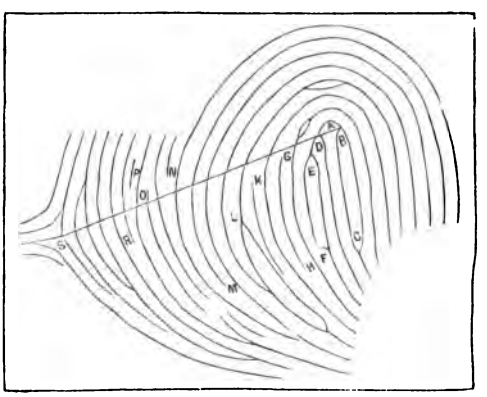


FIG. 42.

judge and assessors, charged with murder and theft, and finally was convicted of having stolen the missing property of the deceased, the assessors holding that it would be unsafe to convict him of murder, as no one had seen the deed committed, but recording their opinion that the charge of theft had been conclusively established against him. This conviction was upheld by the judges of the Supreme Court, to which the case was taken on appeal."

Figs. 39, 40, 41 are copies of the enlargements made from the actual marks by the Survey of India, placed before the Courts that tried the case, and proved in the usual way. Fig. 42 is a drawing by hand to show the ridge *characteristics* relied on; they are marked by the small capital letters, and are fully described.

They appear in all three impressions—in the blood print on the calendar (Fig. 41), in the print on record in the Central Police Office (Fig. 39), and in the print taken from Kangali Charan's thumb after his arrest (Fig. 40). What probative value shall we assign to such distinctive similarities being found in three prints made at intervals of time, and what inference are we in the circumstances of this particular case justified in drawing? The question is of such importance that some space may be devoted to discussing it.

Probative significance of existence in two finger prints of distinctive similarities.—It is known that many of the constituents of the sun and stars have been determined by spectro-

scopic analysis of the light from them which comes to us as a message through space. Transmitted through a glass prism, light so simple in appearance, but in reality complex in its nature, is resolved into its constituent rays, these appearing as bands of various colours with narrow gaps wanting in brightness which show out as dark lines traversing the colours of the spectrum. For nearly half a century after their first discovery by Fraunhoffer their significance was not apprehended, and it was only in 1859 that Kirchhoff proved the dark lines of the spectrum to be caused by the absorbing power of a vapour screen of the same substance, which when sufficiently heated gives out the bright lines. This discovery provided the key which has enabled astronomers to solve many problems which hitherto had baffled them. The spectra of earthly elements having been mapped out, it was possible to compare them with the spectra of the sun and stars, and then marked coincidences in the number, position, and groupings of these lines became apparent. By what process of reasoning are such coincidences held to establish the identity of the sources producing these coinciding lines? The answer is given in the published results of Kirchhoff's investigations. On comparing the spectrum of sunlight and of light from incandescent iron vapour, he found a considerable number, sixty or more bright lines in the spectrum of iron coinciding with dark lines in the solar spectrum. Taking the average distance between these lines as they show on his map, and making allowance for their apparent breadth, he

considers the probability to be $\frac{1}{2}$ that an iron line thrown down by chance will appear to coincide with a solar line. The probability of casual coincidence of each iron line with a solar line is similarly $\frac{1}{2}$. The probability therefore of coincidence by chance of all sixty iron with the sixty solar lines is $\frac{1}{2}$ multiplied by $\frac{1}{2}$ sixty times or $\left(\frac{1}{2}\right)^{60}$. Otherwise expressed, the odds against these coincidences occurring by chance is more than a trillion to one. On the supposition, however, that iron exists in the sun, it is certainly probable that such coincidences would be found.[1]

This argument is held to establish with a probability little short of certainty the existence of iron in the sun. Many other conclusions of astronomy are based upon a similar application of the theory of probability.

Upon like grounds we believe in the human origin of flint heads. For though the actual concussion of one flint against another may produce flakes, yet when several such flint heads are found in the same spot, each bearing evidence of many blows similarly directed, conducing to fashion a lance or spear-head form, the probability of a natural origin becomes extremely small, and the supposition that they are the handiwork of man almost a certainty.

We may now apply this line of reasoning in estimating the probability of specified *characteristics* found in the impression of one digit occurring by chance in that of any other. Taking Fig. 42 and

[1] Kirchhoff, *Researches on the Solar System.*

assuming it to be three chances to one against the bifurcation, B occurring casually in this particular limb of a "staple" and at this particular point of it in another impression selected at random, the probability of such occurrence is $\frac{1}{4}$. The degree of probability here assigned is, it will be conceded, not excessive, for there might be no bifurcation, or if there happened to be a bifurcation it might be in some other position of the limb. Similarly, the probability of bifurcations at D and E occurring by chance is $\frac{1}{4}$ for each; the probability of a ridge beginning abruptly at G may be put down at $\frac{1}{4}$; of its ending abruptly at H at $\frac{1}{4}$; of ridges beginning abruptly at K, M, N, each at $\frac{1}{4}$; the chance of another impression being an *ulnar* Loop with a "staple" for core at $\frac{1}{4}$; and finally, the probability of a second impression having just 17 ridges intervening between its "inner" and "outer terminus" at $\frac{1}{4}$, and so on. Confining our attention to the *characteristics* specially noticed, the probability of all ten occurring by chance in the impression of any other digit is $\frac{1}{4}$ multiplied by $\frac{1}{4}$ ten times, or $\left(\frac{1}{4}\right)^{10}$. In other words, the odds against all these similarities being found in two impressions, not those of the same digit, is over a million to one. Upon the other hypothesis that they are prints of the same digit it is highly probable that such coincidences would occur, and clearly it is immensely more probable that these ten coincidences in the *characteristics* of the ridges should be found if the impressions are

those of the same digit than that they should occur by chance. Figs. 39 and 40 are prints from the same thumb, the one taken in 1895, the other in 1897; they show all the *characteristics* which have been enumerated, and these same *characteristics* are found in the blood print on a calendar, proved to have been in the possession of the deceased from the time of its issue.

It may happen that circumstantial evidence of apparently overwhelming completeness will sometimes lead to a mistaken judgment, but every Court has to act upon probabilities, for if certain evidence, in the strict meaning of the words, were required, no punishments could be inflicted. While, then, realising the importance of carefully distinguishing between the truth of a theory and its truthful application to the facts of a case, can there in this instance be any doubt that the blood print on the calendar is the thumb impression of Kangali Charan?

When finger prints are needed as exhibits in cases, it is often necessary to have photographic enlargements made, so that the magistrate, judge, or jury may be able to see for themselves the similarities or dissimilarities in impressions which are relied on in the case. Such enlargements to be admissible must be proved in the manner laid down by the Law of Evidence, the provisions of which should be consulted by officers concerned in conducting cases in which finger prints are exhibits. According to the existing law, the testimony of finger-print experts is admissible and relevant.

PART II

PART II

Introduction of Anthropometry.—The importance of being able to fix human personality, of being able to give to each human being an individuality differentiating him from all others, under conditions which will ensure that this individuality can be convincingly and quickly ascertained in spite of all efforts that may be made to confuse it, cannot be overestimated. The problem of providing the necessary data was first dealt with successfully in France. M. Bertillon's inquiries having satisfied him that the measurements of certain bony portions of the human frame do not vary during the period between adolescence and extreme old age, he selected head length, head breadth, middle finger length, foot length and cubit, and distributed them as belonging to one or other of three equally numerous classes, "Small," "Medium," "Large." Consequently there are 243 principal headings, under some one of which the card containing each person's measurements is, in the first instant, sorted. Each of these primary headings is successively subdivided on the same general principle, according to height, span, length, and breadth of the ear, height of the bust, and eye colour, this latter

providing seven divisions. In theory, therefore, the number of subdivisions is $3^{10} \times 7$, which represents a number far in excess of requirements. The measurements are taken with instruments, and it is claimed that they can be taken with great accuracy. The system was first practically worked in France in 1890, and soon began to yield such gratifying results that it has since, in a more or less modified form, gradually been adopted by most countries. It represents a scientific solution of what had long been deemed an insoluble problem, and is obviously an enormous improvement upon all rough-and-ready means previously adopted, one of the best known and most successful of which was that of indexing persons according to tattoo marks. Many belonging to the criminal classes are addicted to the practice of having their arms and bodies tattooed, and this fact was turned to account by the police authorities, who started a tattoo index, which, on the whole, has rendered them much useful help.

In March 1892 anthropometry was introduced into the large Province of Bengal, where, as the outcome of much experimenting, it was found desirable to modify the system by taking only six instead of ten measurements, not noting the eye colour, there being little variation in the pigment of the iris amongst Orientals. It was found necessary to use instruments which, by mechanical appliances, had been rendered automatic in their working; the pressure being applied by a spring and kept constant, and a self-registering index being supplied. This

modified system spread to the rest of India, and by the end of 1898 nearly 200,000 cards had been collected in the several provinces. In Bengal, where it had been longest introduced, certain weaknesses in the system showed themselves so detrimental to successful working that attention was directed to the feasibility of substituting a system of indentification by finger prints only, not supplemented by measurements. The main difficulty experienced was that of classification. The system suggested by Mr. Galton had been examined by the Special Committee appointed by Mr. Asquith when Home Secretary in 1894, and they, while recognising its many excellences, were of opinion that it failed to deal as effectively as Bertillonage with primary classification. In consequence, they recommended the adoption of a dual system, under which primary classification should be according to measurements upon M. Bertillon's principles, finger impressions being utilised for secondary or subclassification.

Anthropometric and finger-print systems compared.—By the beginning of 1897 the experiments made in Bengal with the system of identifying by finger prints only, proved so satisfactory that an application was made to the Government of India for the appointment of an independent committee to inquire into and report upon the system. The strong and weak points of anthropometry and the new system were thus compared:

Anthropometry.	*Identification by Finger Prints.*
(1) Instruments are costly, and liable to get out of order.	(1) Accessories needed, a piece of tin and some printer's ink, are inexpensive and procurable everywhere.
(2) Measurers must be put through a special course of instruction and be possessed of sufficient education to understand the significance of the figures of the decimal scale.	(2) Any person, whether educated or not, after half an hour's practice, can take legible finger prints.
(3) If measurements are inaccurately taken, or accurately taken but wrongly read off or wrongly transcribed, the error cannot afterwards be discovered and remedied in the office where the cards are permanently kept, and this error will persist and defeat all chance of successful search. If the data recorded are incorrect, no amount of care can afterwards remedy the defect.	(3) Finger prints are absolute impressions taken from the body itself under conditions which eliminate error as regards transcription or recording. An effective device is adopted to guard against their being imprinted in a wrong sequence. After the "rolled" impression of each digit is taken separately, the digits are confined together in a metal guard and impressed simultaneously as "plain" impressions, thereby securing their occurrence in a correct sequence, and these "plain" impressions are compared with the "rolled" impressions at the time of classification. They may get incorrectly classified, but this error will be subsequently rectified, as it must be noticed during some subsequent search.
(4) Recording measurements takes much time, as to ensure reliability each measurement should be taken three several	(4) The impressions of the ten digits can be taken in less than one quarter the time needed for measuring. No

Anthropometry.

times and the mean result only accepted. Marks and scars are noted, and this necessitates the body being uncovered. The measurements of young persons who have not attained full physical growth alter as they approach maturity.

(5) A margin, greater or less, must always be allowed for errors on the part of the operator for what may be termed the "personal equation" error of operators. This makes search for duplicates particularly onerous. For instance, when a card with length of head 18·4 is received, it is necessary to assume that the operator may have gone wrong within 2 millimetres (a millimetre being about $\frac{1}{25}$ of an inch) either in excess or defect, and search accordingly is made between 18·6 and 18·2, but the former measure may fall under limit "long" and the latter under limit "medium," *i.e.* two pigeon-holes must be examined. Similar allowance has to be made in respect of all the other measurements, with the result that the process of search with a record of 30,000 cards may occupy an hour or longer.

(6) Search is made according to the somewhat complicated

Identification by Finger Prints.

record of marks and scars is required, consequently the subject has not to divest himself of his clothes. The patterns of impressions and the ridges of which they are composed retain their peculiarities absolutely unchangeable throughout life.

(5) No allowance for error on the part of the operator is made or needed. Working results in India show that, in 1898, 500 anthropometric references necessitated 4623 pigeon-holes being searched, whereas 500 finger impression references in 1899 necessitated only 707 pigeon-holes being searched. Under the latter system, on an average, search was exhausted by the examination of $1\frac{1}{2}$ pigeon-holes, the extension of search beyond the one pigeon-hole indicated being made to discount any possible variation in classification; while, under the former, more than 9 pigeon-holes had to be searched. The records were approximately equal in volume.

(6) No Key is required. The searcher decides whether

Anthropometry.

limits and subsidiary limits contained in a figured "Key," the details of which even practised searchers could not be trusted to commit to memory. The preparation of the "search slip" takes time, more particularly when several of the measurements are near the margins which separate "long," "medium," and "short," and many pigeon-holes may be specialised for examination, and this requires close attention to ensure that there shall be no omissions.

(7) The strongest feature of anthropometry is the excellence of the system of primary classification whereby the cards are distributed, according to length and breadth of head, length of left middle finger, length of left forearm, and length of left foot, among 243 pigeon-holes.

Identification by Finger Prints.

the impression of each digit, the digits being arranged in five pairs, is a Whorl (the term including certain Composite patterns), or not a Whorl. If it is a Whorl, he gives it a prescribed numerical value according as it occurs in the first, or second, or third, or fourth, or fifth pair, and the sum of such values gives a result fixing the particular pigeon-hole out of 1024 where the card should be placed. The secondary or subclassification is done equally rapidly and without a Key.

(7) By an arrangement somewhat similar in principle, upon the determination whether the pattern on each digit taken in turn is a Whorl or not a Whorl, finger impressions are, in primary classification, rapidly distributed amongst 1024 pigeon-holes, and effective means of splitting up accumulations by secondary classification are provided.

General Strahan, R.E., Surveyor-General of India, and Mr. A. Pedler, F.R.S., for some years head of the Bengal Meteorological Department, and now Director of Public Instruction, were selected to form a committee. Towards the end of March 1897 they inquired into both systems, and submitted to

the Government of India a Report, the concluding paragraph of which is as follows: "In conclusion, we are of opinion that the method of identification by means of finger prints, as worked on the system of recording impressions and of classification used in Bengal, may be safely adopted as being superior to the anthropometric method—(1) in simplicity of working; (2) in the cost of apparatus; (3) in the fact that all skilled work is transferred to a central or classification office; (4) in the rapidity with which the process can be worked; and (5) in the certainty of the results."[1]

Upon receipt of this Report, the Governor-General in Council, by a Resolution of June 12, 1897, directed that the system of identification of criminals by finger impressions is to be adopted generally in British India. It has since been introduced into the Presidencies of Bombay and Madras, into the Panjab, North-Western Provinces, Bengal, Burma, Central Provinces, and other parts, over an area containing a population of not less than 200 millions. The anthropometric system had been worked in all these provinces except Burma, and between 150,000 and 200,000 anthropometric cards had been collected and classified. For these, finger impressions are now being substituted as rapidly as possible. In Bengal the Criminal Record in 1899 was made up of about 40,000 finger impressions and 8000 anthropometric cards; it is expected that most of the latter will be eliminated within a year, finger impression duplicates being obtained.

[1] See Appendix.

The following table gives working results under the anthropometric and finger-print systems from the time each was introduced. The total number of previous convictions annually proved by all means in Bengal averages about 2200.

Statement showing, for seven years, Recognitions proved in Court, in the Province of Bengal, by the Anthropometric and Finger-print Systems.

Year.	Recognitions by Anthropometry.	Recognitions by Finger Prints.	Total Recognitions by Anthropometry and Finger Prints.	Remarks.
1893	23*	—	23*	* Started in March.
1894	143	—	143	
1895	207	—	207	
1896	334	—	334	
1897	318	174†	492	† Started in June.
1898	148	345	493	
1899	59	569	628	

In the Annual Police Report for Bengal published in 1899, the results of the previous year's working are stated in the following words: "The total number of recognitions effected during the year under review (1898) are the largest recorded, although in the year immediately preceding, owing to the distress which prevailed over large areas of the country, there was abnormal criminality, and greater scope consequently for the working of a system of criminal identification. There seems no reason to doubt that this success will be maintained, since it is due to the greater effectiveness of the new system. Several instances came to notice during the year of recognitions effected by finger

impressions which could not have been made out from the anthropometric data supplied, the original measurements recorded and those subsequently taken exhibiting variations so great as to frustrate all chance of successful search. As before explained, there must be a residuum of error attributable to what may be termed the personal equation of the measurer, however well devised the checks may be, or however good the instruments used. The operator may be slack and not take the measurements with sufficient care, or having taken them correctly he may transcribe them incorrectly. These possible defects are inherent in the system, but do not occur where finger prints are taken. The subject himself impresses his own prints, and it is immaterial whether he presses forcibly or softly, provided that the lineations are visible. He might make these prints in their wrong sequence, but this error would be at once detected by the classifying office, and as a matter of fact has often been discovered and remedied. There are consequently under the new system fewer possibilities of leakage, and there must necessarily be an increase in the number of successful cases." The views here expressed are fully borne out by the results for 1899, which appear to indicate that many identifiable cases may, in preceding years, have escaped recognition by anthropometry.

Primary classification.—The "rolled" impressions of the digits are recorded in their natural order of thumb, index, middle, ring, and little finger—those of the right hand being in line

above, immediately below them the impressions of the corresponding digits of the left hand. At the bottom of the slip the "plain" impressions of the index, middle, and ring fingers of both hands are also taken. It is essential to correct classification that the digits should be printed in their proper sequence; and as it could happen, through inadvertence on the part of the operator, that the impression, say, of the right index might appear as that of the middle or ring finger, the following check is provided. After the "rolled" impressions have been taken, the index, middle, and ring fingers of each hand are placed in a tin guard or mitten with strap, which keeps them in a fixed position, leaving exposed their first phalanges, and while in this position their impressions are simultaneously taken, and must of necessity appear in their proper sequence. When slips are being classified, their "plain" prints are invariably compared with the "rolled" impressions. This check, simple as it may appear, proves completely effective. See Plates 1 and 2.

The impressions are then read off in the following pairs: right thumb and right index; right middle and right ring; right little finger and left thumb; left index and left middle; left ring and left little finger.

In rounded numbers about 5 per cent. of impressions are Arches, 60 per cent. Loops, and 35 per cent. Whorls and Composites, the proportion varying in the several digits, but the relative preponderance of Loops and Whorls being maintained. This fact has been taken into account in devising a system of primary classification.

The proportion of Arches and Composites being relatively small, Arches in primary classification are included under Loops, and Composites under Whorls. In primary classification therefore an impression must be either a Loop (Arches being included) or a Whorl (Composites included). Taking the first pair, the arrangements possible among them are: right thumb a Loop and right index a Loop; right thumb a Loop and right index a Whorl; right thumb a Whorl and right index a Loop; right thumb a Whorl, right index also being a Whorl.

The above exhausts all possible arrangements, and may be thus set out—the numerator letters referring to the thumb or first of the pair, the denominators to the index or second of the pair:

$$\frac{L}{L};\ \frac{L}{W};\ \frac{W}{L};\ \frac{W}{W}$$

We have the same number of combinations for the second pair, and, as each of these can be combined with each arrangement of the thumb and index, the total combinations of the two pairs taken together is 16. The third pair has similarly four arrangements, which, taken with those of the preceding two pairs, raises the number of combinations to 64; adding the fourth pair this number rises to 256, and with the fifth pair to 1024. The number 1024 is the square of 32, so a cabinet containing 32 sets of 32 pigeon-holes arranged horizontally would provide locations for all combinations of Loops and Whorls of the ten digits taken in pairs. The manner in which they

would be arranged in pigeon-holes is shown in Plate 3. In practice it is found more convenient to take impressions, not on cards, but on stout paper foolscap size, termed "slips," and to keep them arranged in open files, each file or, when the accumulations are small, each subdivision of a file corresponding to a pigeon-hole. This enables the whole record to be more easily handled, as the slips can be turned over rapidly, and there is besides considerable saving of bulk, the slips being of less substance than cards. A record consisting of 20,000 sets of slips would pack away into half a dozen small trunks, and within the space of a few minutes could be unpacked and arranged for search.

Plate 3 explains the system of arrangement, and an illustration is given.

Arithmetical rule for determining primary classification, etc.—Simple as is the method of determining the primary classification number with the aid of the Key to the cabinet, it can be even more readily arrived at in the following way, which enables the searcher to dispense altogether with the Key.

The digits, as before, are taken in pairs, the first of the pair being shown as numerator and the second as denominator, the formula thus obtained being of the following kind:

$$\frac{L}{W};\ \frac{W}{L};\ \frac{L}{L};\ \frac{W}{W};\ \frac{L}{W}$$

When a Whorl occurs in the first pair it counts

16, in the second pair it counts 8, in the third 4, in the fourth 2, and in the fifth 1; no numerical value is given to a Loop. The above formula can then be expressed as:

$$\frac{0}{16}; \frac{8}{0}; \frac{0}{0}; \frac{2}{2}; \frac{0}{1}$$

Numerators are added together, also denominators, and the totals exhibited as a new fraction $\frac{10}{19}$. To both numerator and denominator 1 is added, making $\frac{11}{20}$, and this fraction inverted gives the primary classification number $\frac{20}{11}$, which represents that the impression slip will be found in the twentieth pigeon-hole of the eleventh horizontal row.

If instead of the Key given in Plate 3 the following Key be adopted,

LL	WL
LW	WW

the above rule becomes simplified to the extent that no inversion of the fraction obtained by adding together the numerical values given to Whorls in numerators and denominators is required. It may be stated here that the numerical rule was not discovered until after the Key shown in Plate 3 had been brought into use, otherwise the alternative Key might have been adopted with a view to simplifying the numerical rule.

Given the primary classification number, it obviously is easy to work backwards and determine the type of each digit. Taking the primary classification number $\frac{20}{11}$, it is seen that 20 falls short of 32 by 12, which is equivalent to $8+4$; we know therefore that Whorls are wanting in the second and third pairs and in the denominator, for, as above explained, $\frac{20}{11}$ is the inversion of $\frac{11}{20}$. Similarly 11 falls short of 32 by 21, which is equivalent to $16+4+1$, and we know therefore that Whorls are wanting in the first, third, and fifth pairs (numerator). Where Whorls are wanting, Loops must take their place, and so we get back at once to the formula

$$\frac{L}{W}; \frac{W}{L}; \frac{L}{L}; \frac{W}{W}; \frac{L}{W}$$

Classification numbers run not from 1 to 1024 consecutively, but from 1 to 32 of each horizontal row. Thus $\frac{4}{1}$ represents the fourth pigeon-hole or division of the first horizontal row; $\frac{10}{5}$ the tenth division or pigeon-hole of the fifth horizontal row; $\frac{31}{32}$ the thirty-first or last but one pigeon-hole of the last horizontal row.

Slips kept in files.—The practice in Bengal is to protect the slips by keeping them collected according to their classes, arranged between cardboards, each such collection being a file. When the accumulations in several pigeon-holes of the same horizontal row are relatively small, they may be kept in one file, arranged amongst themselves

according to classification numbers. Thus, in a moderate-sized record, the accumulations in all the pigeon-holes of the eleventh horizontal row might be kept in one file, which would be labelled $\frac{1\text{–}32}{11}$, each of the slips contained in it having its correct classification number and subclassification lettering legibly noted on it in pencil, so that should a slip get out of place it can be put back.

When, however, the accumulation under a particular classification number, as $\frac{1}{1}$, is very large, it becomes necessary to have separate files for each of the subclasses.

On a slip being received containing impressions, all of which are Loops except the two index fingers, which are Arches, the searcher would find a dozen files marked $\frac{1}{1}$, and would select from them for purposes of search the particular file labelled $\frac{1}{1}\,\frac{A}{A}$.

It is undesirable to increase overmuch the number of files, but this is a lesser evil than keeping them too bulky for convenient handling. No file should contain slips belonging to pigeon-holes of different horizontal rows, or it may be stated thus: the denominator of the classification numbers of all slips kept in one file must be the same.

Secondary or subclassification.—Owing to the occurrence, under certain primary classification numbers, of large accumulations, secondary or subclassification is required to break them up into

groups of convenient size. Similar trouble is experienced with measurements under the anthropometric system, the tendency where length of head or width of head or length of forearm is "long" or is "short" for the other measurements to be "long" or to be "short" being very noticeable. To secure a fairly even distribution of the cards amongst the 243 pigeon-holes under that system it has been found necessary to provide subsidiary limits, varied according as the forearm is "long," is "medium," or is "short." This will be understood from Plate 4, which is the Key (in use everywhere in India) to the cabinet containing all the measurements of persons whose head length is "medium." There is a similar Key for "long" length of head and for "short" length of head. The limits laid down vary, it will be seen, in all three columns, and no searcher could safely commit them to memory. This Key, in exhibiting how restricted are the range limits, explains why so many searches become necessary when the allowance in excess and defect to discount the personal equation error is made. Such complications do not trammel the finger-print system.

As has been previously stated, the fingers are impressed in their natural sequence, the thumb first, then the index, middle, ring, and little finger, those of the right hand being above and immediately below each of its digits, the corresponding digit of the left hand. The index finger of each hand is taken as a *fulcrum*, the mark specialising it being the capital letter of its symbol, the mark specialising

the thumb being the small letter of its symbol placed to the left of the *fulcrum*, the marks specialising the remaining fingers being the small letters of their symbols to the right of the *fulcrum*. Arches, Tented Arches, and *radial* Loops being of relatively infrequent occurrence are utilised in subdividing, and their presence is invariably noted in the subclassification formula. This formula is in the form of numerator and denominator, the numerator referring to the right, the denominator to the left hand. Formula $\frac{1}{1}\ \frac{\text{aAr}}{\text{rRa}}$ indicates that the slip containing the impressions will be found under classification number $\frac{1}{1}$, and will there be found included in the collection specialised by having an Arch in the right thumb, an Arch in the right index, and a *radial* Loop in one of the remaining digits of the right hand, while the left thumb and index are *radial* Loops, one of the other digits of this hand being an Arch.

Subclasses formed by Arches and radial Loops.—Pigeon-hole or classification number $\frac{1}{1}$ contains the slips all the impressions of which are Loops as distinguished from Whorls (Loops including Arches, Tented Arches, *radial* and *ulnar* Loops); and we have now to consider the methods for dividing its accumulation into subclasses and groups.

Arches, *radial* and *ulnar* Loops may occur in one or both index fingers in nine combinations, as thus exhibited, and when they occur they provide

for the formation of nine subclasses. The letters arranged horizontally refer to the right, those vertically to the left index.

	A	R	U
A			
R			
U			

Under subclass $\frac{A}{A}$ will be found accumulated the slips with an Arch in both index fingers; under $\frac{A}{R}$, those with an Arch in the right and *radial* Loop in the left index; under $\frac{A}{U}$, those with an Arch in the right and *ulnar* Loop in the left index. Similarly there are subclasses:

$$\frac{R}{A};\ \frac{R}{R};\ \frac{R}{U};\ \frac{U}{A};\ \frac{U}{R};\ \frac{U}{U}$$

these nine subclasses representing the nine combinations.

In subclass $\frac{A}{A}$, as Arches may occur in one, two, three, four, or five fingers the number of groups created by utilising them may be thus exhibited:

1	2	3	4	5
a	A	–	–	–
a	A	a	–	–
a	A	–	a	–
a	A	–	–	a
a	A	a	a	–
a	A	a	–	a
a	A	–	a	a
a	A	a	a	a

1	2	3	4	5
–	A	–	–	–
–	A	a	–	–
–	A	–	a	–
–	A	–	–	a
–	A	a	a	–
–	A	a	–	a
–	A	–	a	a
–	A	a	a	a

where 1 denotes the position of the thumb, 2 of the index, 3 of the middle, 4 of the ring, and 5 of the little finger. There will be a like number of groups for the fingers of the other hand, and, as both hands are utilised in splitting up subclasses, the total number that may be created by this device is $16 \times 16 = 256$. An equal number of groups will be created by the occurrence of *radial* Loops in both hands, or of *radial* Loops in one and Arches in the other. In subclasses $\frac{A}{A}$; $\frac{A}{R}$; $\frac{R}{A}$; $\frac{R}{R}$, 256 such groups can be made.

This, however, is a number in excess of requirements, and in practice a smaller number are employed, formed upon deciding whether there are one, two, or three Arches to the right of the index or *fulcrum*. These groups are A; aA; Aa; aAa; A2a; aA2a; A3a; aA3a; they are arranged amongst themselves in the order here given. This substitutes 64 for the possible 256 groups. When Tented Arches take the place of Arches, they are placed below the slips containing Arches to the same number. Thus aAt would be disposed immediately below the aAa group; aAat below the aA2a group. When *radial* Loops occur they are disposed immediately below the groups containing the same number of Arches and Tented Arches; aAr would be placed next below group aAt and aAar below aAat.

In subclasses $\frac{A}{U}$; $\frac{R}{U}$, the numerators provide 16 combinations and the denominators a number of combinations formed by ridge *counting*, the details of which are explained when subclass $\frac{U}{U}$ is being

dealt with. In subclasses $\frac{U}{A}$; $\frac{U}{R}$, there are 16 possible combinations in the denominator and in the numerator, combinations from ridge *counting.*

In subclass $\frac{U}{U}$, although both index fingers are *ulnar* Loops, Arches or *radials* may occur in the remaining digits, and groups can be formed accordingly. This subclass splits into two, the first denoted as $\frac{U}{U}$ (lettered), of which instances are $\frac{aU}{U}$; $\frac{U}{aU}$; $\frac{Ua}{U}$, etc., the term "lettered" referring to the appearance on either side of numerator or denominator of the letters a, r, or t. The other subclass is $\frac{U}{U}$ (unlettered).

Subdivision by ridge counting.—These methods of selection for separate subclasses leave the residuum under subclass $\frac{U}{U}$ in which all the impressions are *ulnar* Loops. The proportion of slips containing such impressions lies between 4 and 5 per cent. of the total record, and necessarily in a large record represents a considerable number of slips, which are, however, reduced to convenient sized groups. The number of ridges which intervene between the "inner" and "outer terminus" can, with the aid of a reading glass and a pointer, be *counted* correctly. A little practice gives the needed accuracy. Trials made with many thousand impressions yield the following results. In the index finger the number of impressions which have from one to nine ridges between the "inner" and "outer terminus" (*both these fixed points being excluded from count*) equals the number of impressions with ten or more than

ten ridges. In the middle finger, the number with from one to ten ridges equals the number with eleven or more. Calling the lower limit I and the higher limit O, taking both index and middle finger of each hand, the number of arrangements possible may be thus set out, the letters horizontally disposed referring to the right index and middle, those vertically to the index and middle of the left hand. This represents 16 groups, viz.:

	II	IO	OI	OO
II				
IO				
OI				
OO				

$$\frac{II}{II};\ \frac{IO}{II};\ \frac{OI}{II};\ \frac{OO}{II};\ \frac{II}{IO};\ \frac{IO}{IO};\ \frac{OI}{IO};\ \frac{OO}{IO};\ \frac{II}{OI};\ \frac{IO}{OI};\ \frac{OI}{OI};\ \frac{OO}{OI};$$

$$\frac{II}{OO};\ \frac{IO}{OO};\ \frac{OI}{OO};\ \frac{OO}{OO}$$

which amongst themselves are arranged in the above order.

The advantage of this method is that in most instances it is possible to decide on view whether the ridge *counts* fall within the lower or higher limit. The eye can decide at a glance that an impression with 15 ridges falls within the O limit, one with 5 within the I limit, and this means much saving of time in subclassifying. It is only when the ridge *count* approaches the limit between I and O that greater accuracy is needed.

In each of these 16 groups the slips are arranged amongst themselves according to the *count* of ridges in the right little finger. This represents a further splitting up, the subgroups thereby created being so small as to render search comparatively easy and

rapid. The full formula for one of these slips would be of the following kind:

$$\frac{1}{1}\ \frac{U}{U}\ \left(\frac{IO}{OI}\right)6.$$

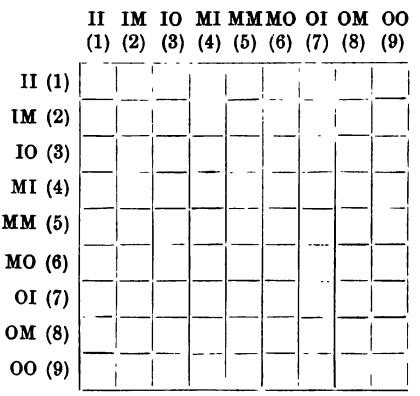
The searcher would proceed to the accumulation of slips marked $\frac{1}{1}$, select the file $\frac{U}{U}$, containing subclass $\frac{U}{U}$, and search in subgroup 6 of group $\left(\frac{IO}{OI}\right)$ of this file.

This application of the principle of *counting* the ridges in four fingers is not confined to subclass $\frac{U}{U}$, but is employed in the other subclasses of $\frac{1}{1}$, and may be employed in classes $\frac{5}{1}$, $\frac{9}{1}$, $\frac{1}{2}$, $\frac{5}{2}$, $\frac{9}{2}$, $\frac{10}{2}$, $\frac{13}{2}$, $\frac{9}{6}$, $\frac{10}{6}$, $\frac{1}{17}$, $\frac{5}{17}$, $\frac{9}{17}$, $\frac{13}{17}$, $\frac{1}{18}$, $\frac{5}{18}$, $\frac{9}{18}$, $\frac{13}{18}$, $\frac{14}{18}$, $\frac{9}{22}$, $\frac{10}{22}$, $\frac{13}{22}$, $\frac{14}{22}$ to break their subclasses into groups when their totals are sufficiently large to require such minute subdivision.

Subdivision by ridge tracing. — There are marked accumulations under the classification numbers, where are collected together the slips containing impressions all or nearly all of which are Whorls (including Composites), and subclassification here is needed. Ridge *tracing* has been explained.

As specialised by the course of the lower limb of the ridge forming the left delta, a Whorl may be I or M or O. The index and middle finger of the right hand being taken, the former may be I or M or O, and the middle finger may also be I or M or O, so the combinations of the two fingers taken together

will be nine, and, when these are taken with the similar arrangements for the corresponding two fingers of the left hand, the total number of combinations rises to eighty-one, each of which represents a separate determinable group. These may be shown in the following diagram, where the letters set out horizontally refer to the right hand, the first of each pair specialising the index and the second the middle finger, while the letters set out vertically refer to the left hand :



The full formula for a slip in which all or nearly all the impressions are Whorls would be of the following kind : $\frac{32}{32}\,\frac{\text{IO}}{\text{MI}}$ or $\frac{31}{32}\,\frac{\text{MM}}{\text{II}}$, where the figures represent the primary and the lettering the subclassification. To further simplify this, the lettering, as can be seen in the diagram, may be more concisely expressed in figures, and the above formulæ would then become $\frac{32}{32}\left(\frac{3}{4}\right)$ or $\frac{31}{32}\left(\frac{5}{1}\right)$, where the figures in brackets denote the groups formed under classification numbers $\frac{32}{32}$

and $\frac{31}{32}$. Amongst themselves these groups are disposed as follows: $\left(\frac{1}{1}\right)$, $\left(\frac{2}{1}\right)$; $\left(\frac{3 \text{ to } 9}{1}\right)$, and then $\left(\frac{1}{2}\right)$, $\left(\frac{2}{2}\right)$, $\left(\frac{3}{2}\right)$, $\left(\frac{4}{2}\right)$, and so on.

Ridge *tracing* in all four fingers is used for splitting up into groups the accumulations under $\frac{27}{28}$; $\frac{31}{28}$; $\frac{32}{28}$; $\frac{28}{32}$; $\frac{31}{32}$; $\frac{32}{32}$, and is applicable to some others when the number of their slips is sufficiently large to necessitate further subdividing.

In Central Pockets, Lateral Pockets, Twinned Loops, most Accidentals, and in a fair proportion of Whorls, the differentiation into I, M, O can be made at a glance. It is only when the Whorl has symmetrically disposed deltas, that is deltas which appear to be at almost the same distance from its core, that careful *tracing* is needed. The labour entailed by noting Whorls as I, M, or O consequently is much less than might seem probable, and after a little practice will be found to have no special difficulties. Cases will occur where, owing to the imperfections of the print, it is not possible to decide with certainty, and in such instances double search is made. Thus, if it is doubtful whether a particular Whorl is I or M, search is made on the assumption first that it is I, and if this fails, search is made on the assumption that it is M.

Classification of damaged or missing fingers.—It is essential that the slips accepted for permanent record shall contain the best impressions procurable. If the prints are clear and the ridges

sharply defined, the task of classifying presents no difficulties. On receipt, the impressions are scrutinised, and if amongst them blurred or imperfect prints are discovered, the slip is returned and a more carefully prepared duplicate called for. As the impressions of convicts are taken within a few days after sentence is passed, this duplicate can be obtained at any time during their detention in jail. Skin disease and injuries have the effect of blurring or effacing the ridges. By allowing time to elapse, the disease may lessen or the effects of the injuries disappear, and the obliterated ridges will grow again and the prints from them regain their normal appearance and sharpness of outline. It should therefore be the rule in all Central Offices not to admit for permanent record, slips containing imperfect impressions, until it is ascertained that better are not procurable.

When a digit is deformed or missing, no imprint of it can be taken, and the space in the slip assigned to it must remain blank. When one digit is deformed or missing, classification is made according to the corresponding digit of the other hand. If the same digit of both hands is missing, the impressions are held to be Whorls, and classification made accordingly. The absence of even more than two digits does not prevent classification.

An interesting case which occurred in 1898 bears upon this point. A lady resident of Highgate near London was found strangled in one of the rooms of her house. There was no obvious clue, but on examination of the premises it was seen that some person had obtained access to her room by means of

the window, as the impressions of the four fingers of both hands were found on the sill, the paint of which was soft enough to retain impressions. A photograph of these marks was taken, and they proved to be legible. If this person had been an ex-convict and the system described in this book had been in force, there would have been little difficulty in making out his identity.

Leaving blank the spaces occupied by the two thumbs, we may suppose that the formula for the eight impressions left on the sill was the following :

$$\frac{\quad}{W};\ \frac{W}{L};\ \frac{L}{\quad};\ \frac{W}{W};\ \frac{L}{W}$$

We have now only to assume that the missing thumbs were first Loops and then Whorls, and search accordingly ; and the search must prove exhaustive. On this assumption we get the following classification formulæ :

$$\frac{L}{W};\ \frac{W}{L};\ \frac{L}{L};\ \frac{W}{W};\ \frac{L}{W}=\frac{20}{11} \qquad \frac{W}{W};\ \frac{W}{L};\ \frac{L}{L};\ \frac{W}{W};\ \frac{L}{W}=\frac{20}{27}$$

$$\frac{L}{W};\ \frac{W}{L};\ \frac{L}{W};\ \frac{W}{W};\ \frac{L}{W}=\frac{24}{11} \qquad \frac{W}{W};\ \frac{W}{L};\ \frac{L}{W};\ \frac{W}{W};\ \frac{L}{W}=\frac{24}{27}$$

If the impressions of the person who climbed up by the sill had been previously taken and recorded at the Central Office, his identity could be at once made out, for his slip must be amongst the accumulations contained under one of the following four Primary Classification numbers : $\frac{20}{11}$; $\frac{24}{11}$; $\frac{20}{27}$; $\frac{24}{27}$.

If three fingers had been missing, search would have to be made under eight, with four fingers missing under sixteen Primary Classification numbers,

The search would necessarily become more onerous with an increase in the number of fingers missing, but would still be practicable.

Subclassification continued. — The methods adopted for breaking up the largest accumulations, viz. those in which all or nearly all the impressions are Loops or are Whorls, having been understood, little difficulty will be experienced with the smaller accumulations. They are dealt with on similar lines, the presence of Arches or Radials being utilised, and ridge *counting* or ridge *tracing*, or both, being employed.

The Primary Classification number having been worked out and recorded, the slip is again inspected. An Arch or Radial in any of the digits at once arrests attention, and its presence shapes subclassification.

In Plate 2, if there were an Arch in the right thumb, the formula would be changed to $\frac{13}{2}\,\frac{aU}{U}$; if in the right middle, to $\frac{13}{18}\,\frac{Ua}{U}$; if in the left middle, to $\frac{13}{18}\,\frac{U}{Ua}$. With a *radial* Loop in the right thumb, it would be $\frac{13}{2}\,\frac{rU}{U}$; in the right middle or little finger, $\frac{13}{18}\,\frac{Ur}{U}$; in the left middle or little finger, $\frac{13}{18}\,\frac{U}{Ur}$; — all these representing groups so small as to need no further subdividing.

With an Arch in both indexes, it would be $\frac{13}{18}\,\frac{A}{A}$; an Arch in one index, $\frac{13}{18}\,\frac{A}{U}$ or $\frac{13}{18}\,\frac{U}{A}$ or $\frac{13}{18}\,\frac{A}{R}$; and with Arches or Radials in the other digits also a large number of groups, as has already been explained at length, could be formed.

Having disposed of the slips in which Arches and

Radials occur, we now deal with the remainder; and it must be understood that the subdivision here described is required only when, owing to the record being very extensive, accumulations become relatively large. If the index and middle of the right hand are Loops, their ridges are *counted*, and the combined result exhibited as numerator of the subclassification fraction (in brackets); if Whorls, their ridges are *traced*, and their combined result exhibited as denominator.

In $\frac{13}{1}\,\frac{U}{U}\left(\frac{IO}{II}\right)$; $\frac{5}{2}\,\frac{R}{U}\left(\frac{II}{OO}\right)$; $\frac{9}{6}\,\frac{U}{U}\left(\frac{OI}{OO}\right)$; $\frac{13}{22}\,\frac{R}{R}\left(\frac{IO}{II}\right)$ the index and middle of both hands being Loops, the numerator and denominator exhibit the combined result of ridge *counting* in the index and middle of right and left hand respectively.

It will be noticed that, when a *radial* occurs in the index alone, the further subdivision is carried out precisely as if it were an *ulnar* Loop, but the group so formed will be found not under subclass $\frac{U}{U}$, but under subclass $\frac{U}{R}$; $\frac{R}{R}$; $\frac{R}{U}$.

In $\frac{11}{4}\left(\frac{IO}{MM}\right)$; $\frac{15}{20}\left(\frac{II}{MO}\right)$; $\frac{14}{20}\left(\frac{OI}{OM}\right)$; $\frac{16}{24}\left(\frac{OI}{IM}\right)$ the numerator represents the combined result of ridge *counting*, the denominator of ridge *tracing*.

In $\frac{27}{12}\left(\frac{MO}{OM}\right)$; $\frac{31}{12}\left(\frac{IM}{MM}\right)$; $\frac{27}{16}\left(\frac{IO}{MI}\right)$; $\frac{28}{16}\left(\frac{MI}{OO}\right)$ both numerator and denominator exhibit the combined result of ridge *tracing*.

In $\frac{17}{9}\left(\frac{MO}{II}\right)$; $\frac{25}{30}\left(\frac{MM}{II}\right)$; $\frac{29}{30}\left(\frac{OM}{OI}\right)$; $\frac{30}{30}\left(\frac{OO}{II}\right)$ the subclassification numerator represents the combined result of ridge *tracing*, the denominator the combined result of ridge *counting*.

When the index and middle of the same hand are of different types, *i.e.* one a Loop and the other a Whorl, the index only is dealt with, its ridge *counting* or ridge *tracing* result alone being exhibited. This applies to both hands.

In $\frac{9}{9}\left(\frac{\mathrm{I}}{\mathrm{II}}\right)$; $\frac{9}{10}\left(\frac{\mathrm{O}}{\mathrm{IO}}\right)$; $\frac{9}{26}\left(\frac{\mathrm{I}}{\mathrm{OI}}\right)$; $\frac{13}{26}\left(\frac{\mathrm{O}}{\mathrm{OI}}\right)$ the right index is a Loop, right middle a Whorl, both left index and middle being Loops: the numerator shows the result of ridge *counting* in the right index only, the denominator the combined result of ridge *counting* in left index and middle.

In $\frac{28}{2}\left(\frac{\mathrm{M}}{\mathrm{I}}\right)$; $\frac{31}{18}\left(\frac{\mathrm{M}}{\mathrm{O}}\right)$; $\frac{31}{22}\left(\frac{\mathrm{I}}{\mathrm{O}}\right)$; $\frac{32}{22}\left(\frac{\mathrm{O}}{\mathrm{I}}\right)$ the right index is a Whorl, the right middle a Loop, the left index a Loop, the left middle a Whorl: the numerator gives the result of ridge *tracing* in the right index only, the denominator the result of ridge *counting* in the left index only.

The largest accumulations are found under Primary Classification numbers $\frac{1}{1}$; $\frac{5}{1}$; $\frac{9}{1}$; $\frac{1}{2}$; $\frac{9}{2}$; $\frac{1}{17}$; $\frac{5}{17}$; $\frac{13}{17}$; $\frac{9}{18}$; $\frac{13}{18}$; $\frac{28}{32}$; $\frac{31}{32}$; $\frac{32}{32}$. The first ten are reduced to groups by utilising the presence of Arches or Radials or by ridge *counting*, the index and middle of both hands in these ten accumulations being Loops. The last three are reduced by ridge *tracing*, the index and middle of both hands being Whorls.

The complete scheme of classification and sub-classification, as explained in preceding pages, is exhibited in Plate 5.

Application of system to police working.—The

manner in which the system works in the Police Department may be described.

A man charged with housebreaking and theft is convicted under the name of Yakúb Khan, son of Ghulam Ali, sentenced to a term of imprisonment, and sent to jail. On the Monday following, the police officer paying his regular visit to the jail, takes the finger impressions of the convicts admitted during the preceding week, including those of Yakúb Khan (Plate 2). On the back of each slip are recorded the name, father's name, and residence of the convict, with dates and full particulars of the case, and the slips thus filled up are forwarded to the Central Office. On receipt there, they are classified by one officer, and his work is tested by another, before they are filed in their respective collections and groups. If, through inattention or haste, the classifier makes a mistake, it will be detected by the testing officer; and as, moreover, the whole Record, by instalments, is systematically examined from time to time with a view to detecting incorrect classification, the likelihood of errors escaping notice is extremely small. No Key, it will have been noticed, is used or is required. The data for classifying are so few and so simple that any person can carry them in his memory —method and accuracy only being needed. The staff at the Central Office, being picked out as men possessing aptitude for the work, by practice soon become experts in it.

After the lapse of a year or two, the Central Office receive from the police of a distant district a slip (Plate 2), containing the finger prints of a man

on trial for theft there, who has given the name of Ghulam Haidar, son of Muhammad Khan, and other information concerning himself, which the inquiries locally made show to be false.

Method of search.—On receipt of the slip one officer draws up the search form containing the full formula, viz. $\frac{13}{18}\,\frac{U}{U}\left(\frac{10}{10}\right)^{10}$, and makes over the slip and the search form to the searcher, who first verifies the correctness of the formula, and then proceeds to search. The type in all the impressions is unmistakable, so there can be no doubt as to the correctness of the Primary Classification number $\frac{13}{18}$—the subclassification $\frac{U}{U}\left(\frac{10}{10}\right)$ of index and middle of the two hands is also obviously correct—but there may be divergence of opinion as to there being exactly 10 *counts* in the right little finger. To eliminate the possibility of error arising from this, he decides to search through the subgroups of $\frac{13}{18}\,\frac{U}{U}\left(\frac{10}{10}\right)$, which have from 8 to 12 *counts* in the right little finger. Being confident of the correctness of his own counting, he would first search the subgroup with 10 *counts* in the little finger, then the subgroups with 11 and 12, and then the subgroups with 9 and 8. If the slip he is looking for is in the Criminal Record, he knows it must be among subgroups 8 to 12 of $\frac{13}{18}\,\frac{U}{U}\left(\frac{10}{10}\right)$, which file he picks out, and he concerns himself no further with ridge *counts*, but concentrates attention upon the salient features of the slip. The right thumb is a Lateral Pocket, the left thumb a Twinned Loop. He turns

the slips of subgroups 8 to 12 over rapidly, much in the same way as a pile of bank notes are looked through, and delays only when he comes to a slip the right thumb impression of which is a Lateral Pocket, and his eye then glances at the left thumb. If it is not a Twinned Loop, he passes on to the next slip, and finally stops at one which has the right thumb a Lateral Pocket, the left thumb a Twinned Loop, and the two ring fingers Central Pockets. He then compares the ridge *characteristics* of one or two impressions on the slip in his hand with the corresponding impressions of the slip in the Record, and if they agree he knows that his search has been successful. The Central Office then inform the requisitioning police that the so-called Ghulam Haidar was, on a specified date, convicted under the name of Yakúb Khan, son of Ghulam Ali, of housebreaking with theft, and give all the information concerning him recorded on the back of their slip, which is sufficient to enable the local police to prove, in the manner prescribed by law, the previous criminality of the *soi-disant* Ghulam Haidar.

Although $\frac{13}{18}$ is amongst the largest of the accumulations, exhaustive search for a duplicate in it, even when the Record consists of 30,000 slips, can be completed within a limit of five or six minutes. A practised person carries photographed on his eye the salient features of the slip he is looking for, and can search for it as rapidly as his hand is able to turn over the Record slips.

Gradational cases.—It will be noticed that the

possibility of search extending beyond subgroup 10 of $\frac{13}{18}\left(\frac{10}{10}\right)$ has been discussed, and this leads to the consideration of what may be termed gradational or transitional cases.

Doubt may arise as to the type of an impression, and consequently as to its correct Primary Classification number. In Plate 1 it might be contended that the right index is not a characteristic Central Pocket, the details of its pattern placing it on the borderline which separates Loops from Central Pockets, and that some persons might classify it as an *ulnar* Loop, others as a Whorl (Central Pocket). If the right index is a Central Pocket, the Primary Classification number is $\frac{26}{2}$, if it is a Loop it would be $\frac{10}{2}$. To eliminate any uncertainty arising from the possibility of varying classification, search is made in the accumulations under both numbers, and in the groups here specialised, viz. $\frac{26}{2}\,\frac{r}{aR}$ and $\frac{10}{2}\,\frac{Ur}{aR}$.

The groups indicated contain few slips in both $\frac{26}{2}$ and $\frac{10}{2}$, and so this double search, even when the Record is very extensive, occupies little time.

Doubt may arise whether there are exactly 9 ridge *counts* in an index finger utilised in subclassifying. If there are 9 or less it is I; if more than 9 it would be O. Search is made first on the assumption that it is I, and then on the assumption that it is O; and this must prove exhaustive. The proportion of cases in which double search is required is small, and, though the prolongation of the process takes up extra time, the arrangement of the files is such that the searcher can pass from file to file or

from group to group rapidly, and is really able to compare the slips as fast as he can turn them over.

Gradational cases, whether known as hybrids, sub-species, varieties, or under other names, are common to all sciences. A definition can only make known a finite number of the characteristics of an object selected as the type, and it is always possible that objects agreeing in the assigned characteristics may differ in others, and by gradation, insensibly varying from each other, depart more and more from the defined type.

When it is realised that even at the present time no rigorous boundary can be laid down between the vegetable and animal kingdoms, it will not appear anomalous that gradational forms should occur in any system of finger-print classification however carefully worked out. That their occasional presence in no degree hampers the application of the system to practical working, will be manifest to those who have the opportunity of conducting searches under it.

APPENDIX

REPORT OF COMMITTEE TO EXAMINE INTO THE SYSTEM OF IDENTIFICATION BY FINGER IMPRESSIONS

UNDER instructions from the Government of India, the undersigned met in the office of Mr. Henry, Inspector-General of Police, Lower Provinces, on the 29th March 1897, to report on his system of identification by finger impressions.

2. Mr. Henry first explained the present, or anthropometrical, system of identification by measurements and its classification, which has yielded excellent and progressively improving results each year. During 1896, four out of every possible ten cases were identified. But the system has weak points—

(*a*) Skilled persons are required to take the measurements, and they must have sufficient education to enable them to read the instruments and to use the decimal notation. This is more particularly a serious objection in India, where warders and policemen are frequently far from well-educated men.

(*b*) Carefully made and delicate instruments are necessary to take the measurements with sufficient accuracy.

(*c*) The number of measurements to be taken is considerable, viz.: 3 for the length of head, 3 for the width of head, 3 for length of left forearm, 3 for length of left foot, 3 for length of left little finger, and 3 for height—or 18 in all; the mean of each group of 3 is taken as the final measurement. In addition to these, marks and scars are searched for, and so the actual anthropometric

record of one person occupies the measurer between half an hour and one hour.

(*d*) Owing to the liability to error in measuring or in recording the measurements, notwithstanding that the instruments used, *i.e.* callipers and sliding bars, have been rendered automatic in their working, and, in the former case, self-registering also, it has been found desirable to allow for a possible variation of 2 millimetres in excess and in defect of the measurements. This necessitates, in some cases, search being made in ten or even twelve different pigeon-holes for the duplicate of a case which is being tested, to ensure its not being passed over. The average time of search, therefore, under this system exceeds one hour.

As an instance of how inaccuracies will creep in, the last card, of which the original had just been discovered, showed two errors or variations in measurements, one being as much as 3½ millimetres.

3. After having seen the anthropometric system and having noted its defects, the system of finger impression was carefully examined. The first thing that struck us was the facility with which the impressions were made, and the clearness of the impressions themselves; every little detail being, as a rule, sharply defined and easily seen with the help of an ordinary magnifying glass. The method of taking them is simplicity itself; all the materials required are, a flat piece of tin, a bottle of ordinary printer's ink, and a small rubber roller to spread the ink on the tin. The finger is rolled carefully, without rubbing, on the inked tin, and then on to paper: to take impressions of all the ten digits occupies only five minutes or less, and in this short time an absolutely accurate record, without any possibility of accidental error, is obtained, without skilled labour and without instruments.

4. The method of classification devised by Mr. Henry was then explained to us. The first classification divides all the different kinds of impressions into two classes only, which can be recognised at a glance; by taking the combinations of these two classes, as exhibited in the ten different digits taken in pairs,

all descriptive cards can be divided into 1024 classes, and to each class is allotted a separate pigeon-hole. By means of the Key, a copy of which is attached, any one pigeon-hole can be at once found with the greatest ease, and certainly even by a person who has never seen the system before. We were both enabled to do this at once without any difficulty. Having thus located the card in one particular pigeon-hole, a further classification is necessary to assist in the search through all the different cards in that pigeon-hole; this further classification depends on the details in the impressions, which it is unnecessary to enter into here, but it is so simple that we were both able to find the originals of two of the most intricate cards that could be produced, with ease and certainty. The men whose duty it is to look up the originals, in no case took more than five minutes to produce the original, the duplicate of which we had handed to them out of a file of some six hundred records, and the originals of which were part of a file of finger-print cards exceeding eight thousand in number. One case which was selected as being apparently an especially difficult one, as it was very indistinct, was found in two minutes only. The principles of the subclassification are such that should minute distribution be needed in consequence of any great accumulation in any one pigeon-hole, it can easily be made by extending the same principles. The system of search is therefore much more rapid and more certain than that for the anthropometric data.

5. The greatest sceptic would be at once convinced of identity on being shown the original and duplicate impressions. The exact repetition of most minute details is quite astonishing. There is no possible margin of error, and there are no doubtful cases.

6. Thus the three main conditions laid down by the Committee appointed by the Secretary of State to inquire into the best means available for identifying habitual criminals are fully satisfied, viz.—

(1) The descriptions, measurements or marks, which are the basis of the system, must be such as can be taken readily and with sufficient accuracy by prison warders or police officers of ordinary intelligence.

(2) The classification of the description must be such that, on the arrest of an old offender who gives a false name, his record may be found readily and with certainty.

(3) When the case has been found among the classified descriptions, it is desirable that convincing evidence of identity should be afforded.

In that same report it is acknowledged that Mr. Galton's finger-print method completely met the first and third conditions, but they disapproved of his method of classification. Mr. Henry's method of classification and subclassification has, we consider, effectually got over the objections raised by them, for, out of eight thousand cards, no subclass contained more than from ten to twenty originals, and the system is capable of almost endless amplification, if necessary.

7. In conclusion, therefore, we are of opinion that the method of identification of habitual criminals by means of finger prints as worked on the system of recording impressions, and of classification devised by Mr. Henry, may be safely adopted as being superior to the anthropometric method, (1) in simplicity of working, (2) in the cost of apparatus, (3) in the fact that all the skilled work required is transferred to the central or classification bureau, (4) in the rapidity with which the process can be worked, and (5) in the certainty of the results.

C. STRAHAN, R.E., *Major-General,*
Surveyor-General of India.

ALEX. PEDLER, F.R.S.,
Principal, Presidency College,
Calcutta.

The 31*st March* 1897.

PLATE 4.

KEY TO ANTHROPOMETRIC CABINET B.

I.—Length of Head.

Medium 18·55 to 18·1.

II.—Width of Head.

Long 14·35 and upwards.
Med. 14·3 to 13·95.
Short 13·9 and downwards.

III.—Left Middle Finger.

	Long 11·05 and upwards.	Med. 11·0 to 10·55.	Short 10·5 and downwards.
	IV.—Left forearm— Long 47·45 and upwards. Med. 47·4 to 46·35. Short 46·3 and downwards.	IV.—Left forearm— Long 45·7 and upwards. Med. 45·65 to 44·8. Short 44·75 and downwards.	IV.—Left forearm— Long 43·9 and upwards. Med. 43·85 to 42·9. Short 42·85 and downwards.
Long left forearm.	V.—Left foot— Long 26·4 and upwards. Med. 26·35 to 25·7. Short 25·65 and downwards. VI.—Height— Long 5′ — 7⅝″ and upwards. Med. 5′ — 7⅛″ to 5′ — 6¼″. Short 5′ — 6⅛″ and downwards.	V.—Left foot— Long 25·35 and upwards. Med. 25·3 to 24·7. Short 24·65 and downwards. VI.—Height— Long 5′ — 5¾″ and upwards. Med. 5′ — 5⅝″ to 5′ — 4¾″. Short 5′ — 4⅝″ and downwards.	V.—Left foot— Long 24·5 and upwards. Med. 24·45 to 23·9. Short 23·85 and downwards. VI.—Height— Long 5′ — 4⅛″ and upwards. Med. 5′ — 4⅜″ to 5′ — 3¼″. Short 5′ — 3⅜″ and downwards.
Medium left forearm.	V.—Left foot— Long 25·85 and upwards. Med. 25·8 to 25·25. Short 25·2 and downwards. VI.—Height— Long 5′ — 6½″ and upwards. Med. 5′ — 6⅜″ to 5′ — 4¾″. Short 5′ — 4⅜″ and downwards.	V.—Left foot— Long 24·8 and upwards. Med. 24·74 to 24·3. Short 24·25 and downwards. VI.—Height— Long 5′ — 4⅝″ and upwards. Med. 5′ — 4½″ to 5′ — 3⅝″. Short 5′ — 3½″ and downwards.	V.—Left foot— Long 24·0 and upwards. Med. 23·95 to 23·5. Short 23·45 and downwards. VI.—Height— Long 5′ — 3″ and upwards. Med. 5′ — 2¾″ to 5′ — 2″. Short 5′ — 1⅜″ and downwards.
Short left forearm.	V.—Left foot— Long 25·4 and upwards. Med. 25·35 to 24·7. Short 24·65 and downwards. VI.—Height— Long 5′ — 5⅛″ and upwards. Med. 5′ — 5″ to 5′ — 3¾″. Short 5′ — 3⅝″ and downwards.	V.—Left foot— Long 24·8 and upwards. Med. 24·75 to 24·3. Short 24·25 and downwards. VI.—Height— Long 5′ — 3½″ and upwards. Med. 5′ — 3⅜″ to 5′ — 2⅛″. Short 5′ — 2″ and downwards.	V.—Left foot— Long 23·4 and upwards. Med. 23·35 to 22·8. Short 22·75 and downwards. VI.—Height— Long 5′ — 1¾″ and upwards. Med. 5′ — 1⅝″ to 5′ — 0½″. Short 5′ — 0⅜″ and downwards.

PLATE 5.

SYNOPSIS OF CLASSIFIED COLLECTION

File.	Subfile.	Group.	File.	Subfile.	Group.	File.	Subfile.	Group.
1	A		1	A		1	A	
1	A		1	A		1	A	
,,	,,	A / A	,,	,,	A / A2a	,,	,,	A3a / aA
,,	,,	aA / A	,,	,,	aA / A2a	,,	,,	aA3a / aA
,,	,,	Aa / A	,,	,,	Aa / A2a	,,	,,	A / Aa
,,	,,	aAa / A	,,	,,	aAa / A2a	,,	,,	aA / Aa
,,	,,	A2a / A	,,	,,	A2a / A2a	,,	,,	Aa / Aa
,,	,,	aA2a / A	,,	,,	aA2a / A2a	,,	,,	aAa / Aa
,,	,,	A3a / A	,,	,,	A3a / A2a	,,	,,	A2a / Aa
,,	,,	aA3a / A	,,	,,	aA3a / A2a	,,	,,	aA2a / Aa
,,	,,	A / aA	,,	,,	A / aA2a	,,	,,	A3a / Aa
,,	,,	aA / aA	,,	,,	aA / aA2a	,,	,,	A / aAa
,,	,,	Aa / aA	,,	,,	Aa / aA2a	,,	,,	aA / aAa
,,	,,	aAa / aA	,,	,,	aAa / aA2a	,,	,,	Aa / aAa
,,	,,	A2a / aA	,,	,,	A2a / aA2a	,,	,,	aAa / aAa
,,	,,	aA2a / aA	,,	,,	aA2a / aA2a	,,	,,	A2a / aAa

File.	Subfile.	Group.
1/1	A/A	
,,	,,	aA2a / aAa
,,	,,	A3a / aAa
,,	,,	aA3a / aAa
,,	,,	A3a / aA2a
,,	,,	aA3a / aA2a
,,	,,	A / A3a
,,	,,	aA / A3a
,,	,,	Aa / A3a
,,	,,	aAa / A3a
,,	,,	A2a / A3a
,,	,,	aA2a / A3a
,,	,,	A3a / A3a
,,	,,	A / aA3a
,,	,,	aA / aA3a
,,	,,	Aa / aA3a
,,	,,	aAa / aA3a
,,	,,	A2a / aA3a

File.	Subfile.	Group.
1/1	A/A	
,,	,,	aA2a / aA3a
,,	,,	A3a / aA3a
,,	,,	aA3a / aA3a
1	R/A	R / A
		aR / A
		Ra / A
		And so on, representing 64 groups, corresponding to those of 1/1 A/A
1/1	U/A	
1	A	
1	R	
1	R/R	
1	U/R	
1	A/U	
1	R/U	

File.	Subfile.	Group.
1/1	U/U	

Subfile 1/1 U forms two Subfiles, viz.: 1/1 U (lettered), in which, though both index fingers are ulnar Loops, some of the other digits are Arches or Radials, and Subfile 1/1 U, in which all the digits are ulnar Loops. For details see next page.

Each having 64 groups, corresponding to those of 1/1 A/A

File.	Subfile.	Group.	File.	Subfile.	Group.	File.	Subfile.	Group.
1/1	U/U	(Lettered.)	1/1	U/U	II/IO	32/32		II/II
,,	,,	aU/U	,,	,,	IO/IO	,,		IM/II
,,	,,	Ua/U	,,	,,	OI/IO	,,		IO/II
			,,	,,	OO/IO			
			,,	,,	II/OI			
			,,	,,	IO/OI			
			,,	,,	OI/OI			
			,,	,,	OO/OI			
			,,	,,	II/OO			
			,,	,,	IO/OO			
			,,	,,	OI/OO			
			,,	,,	OO/OO			
1/1	U/U	II/II						
,,	,,	IO/II						
,,	,,	OI/II						
,,	,,	OO/II						

With groups similar to those of 1/1 A/A

Each of these 16 groups can be formed into about 16 sub-groups, according to ridge counts of right little finger.

And so on. As both indexes and both middles are Whorls, the index may be I, M, or O, also the middle may be I, M, or O. Taken together, there are 9 variations for each hand, or, for the two hands together, 81 groups.

File.	Subfile.	Group.	File.	Subfile.	Group.	File.	Subfile.	Group.
13/26		I/II	11/2		II/I	32/24		I/II
,,		O/II	,,		IO/I	,,		M/II
,,		I/IO				,,		O/II
		And so on. Right index being Loop, but right middle a Whorl, only 2 variations in numerator. Left index and middle being Loops, there are 4 variations in denominator, which, for two hands together, give 8 groups.			And so on. Right index and middle being Loops, there are 4 variations in numerator. Left index being Loop, but left middle a Whorl, there are 2 variations in denominator. So the two hands together give 8 groups.			And so on. Right index a Whorl; but as right middle is Loop, there are only 3 variations in numerator. As both left index and middle are Whorls, there are 9 variations in denominator, or, for two hands together, 27 groups.
			11/10		I	29/28		II/I
			,,		I	,,		IM/I
					O/I			
					And so on. Both middles being Whorls, there are only 2 variations in numerator for right index, which is Loop, and 2 in denominator for left index, also a Loop, making 4 groups, both hands being taken together.			And so on. Right index and middle being Whorls, there are 9 variations in numerator; but as left middle is Loop, left index only being Whorl, there are 3 variations in denominator, or, for two hands taken together, 27 groups.

The presence of an Arch or *radial* Loop in the index finger provides for the formation of a subfile or subclass.

The presence of Arches or *radial* Loops in digits other than the index fingers provides for the formation of additional groups.

File.	Subfile.	Group.	File.	Subfile.	Group.	File.	Subfile.	Group.
17/3		I/I	31/18		I/I	13/28		I/I
		M/I			M/I			O/I
		And so on. Both index fingers being Whorls, both middles being Loops, there are 3 variations in numerator and 3 in denominator, providing 9 groups.			And so on. Right index a Whorl, but middle a Loop, so 3 variations in numerator. Left index a Loop, left middle a Whorl, so 2 variations in denominator, in all 6 groups.			And so on. Right index being Loop, but right middle a Whorl, there are 2 variations in numerator. Left index being Whorl, but left middle a Loop, there are 3 variations in denominator, making 6 groups.
29/30		II/II	15/20		II/II			
		IM/II			IO/II			
		And so on. Right index and middle being Whorls, there are 9 variations in numerator. Left index and middle being Loops, there are 4 variations in denominator, yielding 36 groups.			And so on. Right index and middle Loops, so 4 variations in numerator. Left index and middle Whorls, so 9 variations in denominator, making 36 groups.			

The presence of an Arch or *radial* Loop in the index finger provides for the formation of a subfile or subclass.

The presence of Arches or *radial* Loops in digits other than the index fingers provides for the formation of additional groups.

will be found below the last slip of $\frac{1}{1}\ \frac{tAa}{aA}$, or if there be none, then below $\frac{1}{1}\ \frac{aAa}{aA}$, or failing this, then below $\frac{1}{1}\ \frac{Aa}{aA}$.

When files contain large accumulations, they are, for convenience, broken into subfiles, only some of which are exhibited here, this arrangement depending upon the size of the files.

Subclassification reduces the accumulations of files to relatively small aggregations (groups), so as to facilitate search.

By utilising the presence of Arches, Tented Arches, and Radials, and by ridge *counting* and ridge *tracing*, files are split up into 4, 6, 8, 9, up to 24, 36, 81 and more groups, and can, if necessary, be further reduced to subgroups, the volume of the subdivisions thus made being so small as to render search easy and exhaustive. The letterpress explains how this is carried out.

Primary classification numbers $\frac{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 13,\ 14}{1,\ 2,\ 5,\ 6,\ 17,\ 18,\ 21,\ 22}$, representing 64 files, viz.: $\frac{1}{1}$, $\frac{2}{1}$, $\frac{5}{1}$, etc., $\frac{1}{2}$, $\frac{2}{2}$, $\frac{5}{2}$, etc., $\frac{1}{5}$, $\frac{2}{5}$, $\frac{5}{5}$, etc. etc., are subdivisible as $\frac{1}{1}$ (details of which are exhibited) when their accumulations are large enough to require subdivision.

Of these $\frac{1}{1}$, $\frac{5}{1}$, $\frac{9}{1}$, $\frac{13}{1}$, $\frac{1}{2}$, $\frac{5}{2}$, $\frac{9}{2}$, $\frac{13}{2}$, $\frac{9}{6}$, $\frac{1}{17}$, $\frac{5}{17}$, $\frac{9}{17}$, $\frac{13}{17}$, $\frac{1}{18}$, $\frac{5}{18}$, $\frac{9}{18}$, $\frac{13}{18}$, $\frac{9}{22}$, $\frac{10}{22}$ are large accumulations.

Files $\frac{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 13,\ 14}{9,\ 10,\ 13,\ 14,\ 25,\ 26,\ 29,\ 30}$ are subdivisible as $\frac{13}{26}$. Of these none are large accumulations.

Files $\frac{3, 4, 7, 8, 11, 12, 15, 16}{1, 2, 5, 6, 17, 18, 21, 22}$ are subdivisible as $\frac{11}{2}$.

Of these $\frac{11}{2}$, $\frac{15}{20}$, $\frac{16}{22}$ are moderate-sized accumulations.

Files $\frac{3, 4, 7, 8, 11, 12, 15, 16}{9, 10, 13, 14, 25, 26, 29, 30}$ are subdivisible as $\frac{11}{10}$.

Of these none are large accumulations.

Files $\frac{19, 20, 23, 24, 27, 28, 31, 32}{11, 12, 15, 16, 27, 28, 31, 32}$ are subdivisible as $\frac{32}{32}$.

Of these $\frac{27}{12}$, $\frac{28}{16}$, $\frac{27}{28}$, $\frac{31}{28}$, $\frac{32}{28}$, $\frac{27}{32}$, $\frac{28}{32}$, $\frac{31}{32}$ are large accumulations.

Files $\frac{19, 20, 23, 24, 27, 28, 31, 32}{3, 4, 7, 8, 19, 20, 23, 24}$ are subdivisible as $\frac{32}{24}$.

Of these $\frac{31}{20}$, $\frac{31}{24}$, $\frac{32}{24}$ are large accumulations.

Files $\frac{17, 18, 21, 22, 25, 26, 29, 30}{11, 12, 15, 16, 27, 28, 31, 32}$ are subdivisible as $\frac{29}{28}$.

Of these $\frac{29}{27}$, $\frac{29}{28}$, $\frac{29}{32}$, $\frac{30}{32}$ are moderately large accumulations.

Files $\frac{17, 18, 21, 22, 25, 26, 29, 30}{3, 4, 7, 8, 19, 20, 23, 24}$ are subdivisible as $\frac{17}{3}$.

Of these $\frac{21}{19}$, $\frac{25}{20}$, $\frac{29}{20}$, $\frac{29}{24}$, $\frac{30}{24}$ are large accumulations.

Files $\frac{17,\ 18,\ 21,\ 22,\ 25,\ 26,\ 29,\ 30}{9,\ 10,\ 13,\ 14,\ 25,\ 26,\ 29,\ 30}$ are subdivisible as $\frac{29}{30}$. There are no large accumulations.

Files $\frac{17,\ 18,\ 21,\ 22,\ 25,\ 26,\ 29,\ 30}{1,\ 2,\ 5,\ 6,\ 17,\ 18,\ 21,\ 22}$ are subdivisible as $\frac{17}{1}$. Of these $\frac{17}{1}$, $\frac{25}{1}$, $\frac{25}{2}$, $\frac{21}{17}$, $\frac{29}{17}$, $\frac{25}{18}$, $\frac{29}{18}$, $\frac{30}{22}$ are large accumulations.

Files $\frac{19,\ 20,\ 23,\ 24,\ 27,\ 28,\ 31,\ 32}{9,\ 10,\ 13,\ 14,\ 25,\ 26,\ 29,\ 30}$ are subdivisible as $\frac{32}{30}$. Of these none are large accumulations.

Files $\frac{19,\ 20,\ 23,\ 24,\ 27,\ 28,\ 31,\ 32}{1,\ 2,\ 5,\ 6,\ 17,\ 18,\ 21,\ 22}$ are subdivisible as $\frac{31}{18}$. Of these none are large accumulations.

Files $\frac{3,\ 4,\ 7,\ 8,\ 11,\ 12,\ 15,\ 16}{3,\ 4,\ 7,\ 8,\ 19,\ 20,\ 23,\ 24}$ are subdivisible as $\frac{15}{20}$. Of these none are large accumulations.

Files $\frac{3,\ 4,\ 7,\ 8,\ 11,\ 12,\ 15,\ 16}{11,\ 12,\ 15,\ 16,\ 27,\ 28,\ 31,\ 32}$ are subdivisible as $\frac{15}{28}$. Of these $\frac{15}{28}$ is the only accumulation of any size.

Files $\frac{1\ 2,\ 5,\ 6,\ 9,\ 10,\ 13,\ 14}{3,\ 4,\ 7,\ 8,\ 19,\ 20,\ 23,\ 24}$ are subdivisible as $\frac{13}{20}$. Of these $\frac{1}{3}$, $\frac{5}{19}$, $\frac{13}{19}$, $\frac{13}{20}$, $\frac{14}{24}$ are moderate-sized accumulations.

Files $\frac{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 13,\ 14}{11,\ 12,\ 15,\ 16,\ 27,\ 28,\ 31,\ 32}$ are subdivisible as $\frac{13}{28}$. Of these none are large accumulations.

This Synopsis can be used for any collection, however large.

INDEX

ACCIDENTALS, 45.
Accumulations, *see* Classification.
Anthropometric system, described, 61, 62, 63; objections to, 64, 65, 69, 95.
Appliances used, 14.
Arches, 17, 20, 23; Tented, 23, 24.
Asquith, Right Honourable H. H., 63.

BENGAL, 6, 7, 63, 67, 68, 95.
Bertillon, 61.
Bewick, 3.
Bombay, 67.
Burma, 67.

CABINET, anthropometric, 61, 62; finger print, Plate 3.
Callipers used in India, 62, 96.
Callosities, 11.
Capital letters, use of, 76, 77.
Cards, 65, 72, 96; *see* Slips.
Central Pocket Loops, 33, 34, 37.
Central Provinces, 67.
Characteristics of ridges, 46, 47, 54, 57, 58.
Chinese immigrants, 4.
Classification, anthropometric, 61, 62.
Classification (finger prints), Primary, 69, 70, 71; provides 1024 classes, 71; rolled and plain impressions taken, 69, 70; Arches included under Loops, Composites under Whorls, 71; sequence of digits, 69, 70; precaution to ensure correct sequence, 70; upon mathematical basis, 71; arithmetical rule for determining primary classification numbers, 72, 73; type of digits ascertainable from numerical formulæ, 74; accumulations under certain numbers, 75; system explained in Plate 3.
Classification (finger prints), Secondary, required to break up accumulations, 77; presence of Arches, Tented Arches, Radials utilised in, 77, 78, 79; ridge counting utilised in, 80, 81; ridge tracing utilised in, 82, 83; index finger used as fulcrum, 76, 77; complete scheme of, shown in Plate 5.
Combinations used in classification, 71, 72.
Committee, Mr. Asquith's, 63; of Government of India, 63, 67, 95.
Composites, 33.
Core, 19.
Counting ridges, *see* Ridges.
Creases, 10, 11, 12.
Criminal record, 67.
Cubit, 61.
Cut, 11, 12.

DELTA, 18.
Deformed digits, 84, 85.
Digits, order of, *see* Classification.
Denominator of formulæ, 71, 72, 75, 77.

EMIGRATION DEPARTMENT, finger prints used in, 7.
Examinations, public, finger prints used at, 8.
Evidence, law of, applicable to system, 9, 58.

FILES, 74, 75.
Finger prints, *see* Impressions.
Fixed points, 18.
Flakes, flintheads, human origin of, inferred, 56.
Foot-length, 61, 62.
Fraunhoffer, 55.
Fulcrum, 76, 77.

GALTON, DR. F., 3, 4, 5, 12, 13, 17, 98.
Gradational forms, 93, 94.
Groups, 76, 79.
Guard metal, 64, 70.

HEAD, breadth, 61; length, 61.
Herschel, Sir William, 4.
Horizontal rows of cabinet, 74.

IDENTIFICATION, figures of, in Bengal, 68; practical instance of, 50, 51, 54.
Impressions, 15, 16, 17, 18.
Index finger, sequence of, 69, 70; used as fulcrum, 76.
Individuality, human, 61.
Ink used, 16.

Inner terminus, *see* Fixed Points.
Inside as applied to ridges, *see* Ridges.
Insurance offices, use of finger prints to, 8, 9.

KEY to anthropometric cabinet, Plate 4; finger-print cabinet, Plate 3.
Kirchhoff, 55, 56.

LATERAL Pocket Loops, 37; Differentiated from Twinned Loops, 42.
Leakage, 69.
Little finger, sequence of, 69, 70; counts in, 81.
Loops, 25; Ulnar, 25, 28; Radial, 25, 28.

MEASUREMENTS, anthropometric, 61, 64, 65.
Medical Department, finger prints used in, 8.
Meeting as applied to ridges, *see* Ridges.
Missing digits, how dealt with, 84, 85, 86.
Mitten, *see* Guard.

NUMBER of digits impressed, 70.
Numerator of formulæ, 71, 72, 77.
North-Western Provinces, 67.

OBJECTIONS to anthropometry, 60, 65, 66, 69, 95.
Opium Department, finger prints used in, 7.
Order of impressing and reading digits, 69, 70.
Outer terminus, *see* Fixed Points.
Outside as applied to ridges, *see* Ridges.
Oxidisation of ink, 16.

PANJAB, 67.
Paper used, 14, 16.
Papillary, *see* Ridges.
Patterns formed by ridges, 10.
Pedler, Mr. A., 66, 95.
Pensions Department, finger prints used in, 6.
Persistence of patterns and characteristics, 5, 12, 13.
Personation, false, 4, 6, 7, 8.
Personal equation error, 65, 76.
Photographic enlargements, 16.
Pilgrimage, 8.
Plain and rolled impressions, 14, 15, 16, 17, 70.
Pocket, meaning of, 34, 37.
Point of core, 19.
Pointer, 14.
Police, system as applied to, 6, 48, 49, 68, 99.
Post Office, finger prints used in, 8.
Practical instance of working, 50, 51, 52, 53, 54.
Primary, *see* Classification.
Printing, instructions for, 15, 16.
Probative value of system discussed, 55, 56, 57.
Purkenje, 3, 17.

RADIAL, *see* Loops.
Reading glass, 14.
Record, *see* Criminal Record.
Registration Department, finger prints used in, 6, 7.
Results of working of anthropometric and finger-print systems exhibited, 68.
Ridges, described, 10, 11; uses of, 10, 11; persistence of, 12, 13; effect of injuries to, 11; characteristics of, 46, 47, 57; counting ridges, 45, 46, 80, 81; tracing ridges, 47, 48, 82, 83.
RING finger, sequence of, 69, 70.
Rod, 19.
Rolled and plain impressions, 14, 15, 16, 17.
Roller used, 14,

SCARS, 12.
Search, 65, 91, 92, 97.
Secondary classification, *see* Classification.
Skin disease, effects of, 85.
Slab, 14.
Slips, 72.
Solar system, *see* Kirchhoff.
Staple, 19.
Strahan, Major-General, 66, 95.
Subclasses, *see* Classification.
Survey of India, finger prints used by, 7, 8.
Sweat glands, 10.
Symbols used, 50.
Synopsis of whole scheme of classification, Plate 5.

TERMINUS, *see* Fixed Points.
Testamentary dispositions, 9.
Thumb, sequence of, 69, 70.
Time taken to search, *see* Search.
Tin slab, 14.
Tracing ridges, *see* Ridges.
Transitional, *see* Gradational.
Twinned Loops, 42; Differentiated from Lateral Pocket Loops, 42.
Type patterns, 5, 17.

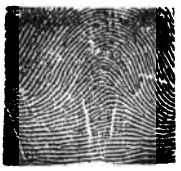
ULNAR, *see* Loops.

WHORLS, 29, 33.

ILLUSTRATIONS.

Arches

1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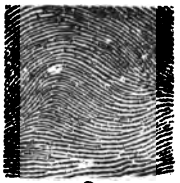
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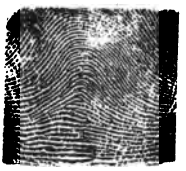
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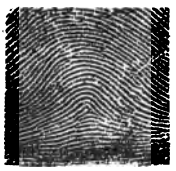
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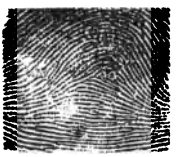
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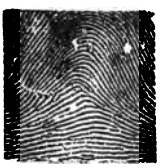
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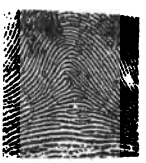
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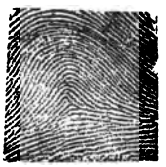
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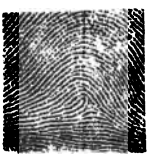
Loops approximating Arches

13

14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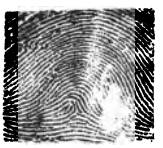
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Tented Arches

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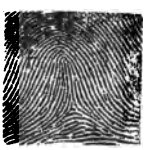
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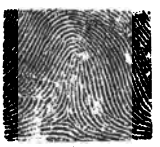
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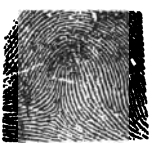
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23

24

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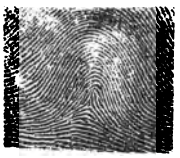
Loops approximating Tented Arches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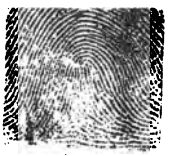
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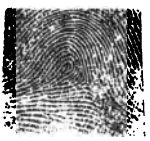
Loops

28

29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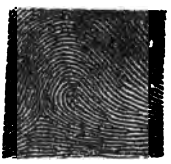
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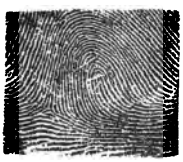
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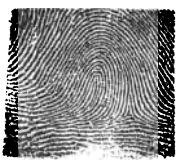
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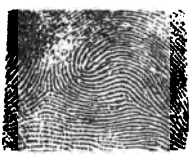
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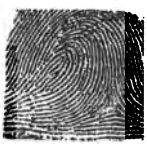
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39

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41

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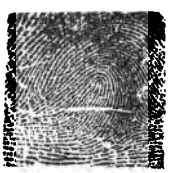
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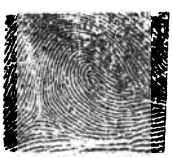

44

45

46

47

ILLUSTRATIONS.

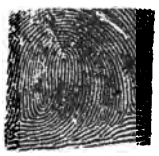
Loops

48

49

Lateral Pocket Loops

50



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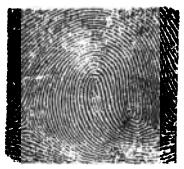

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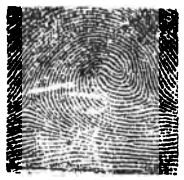

53

54

55

56

57

Loops approximating Lateral Pocket Loops

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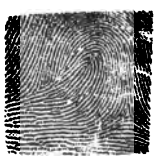

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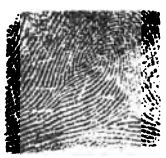

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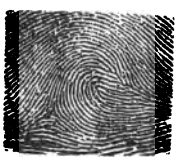

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Twinned Loops

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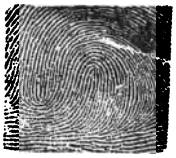
Twinned Loops



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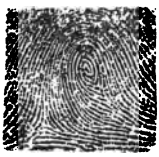
Central Pocket Loops—Standard I



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Loops approximating Standard I

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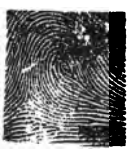
76



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Central Pocket Loops—Standard II

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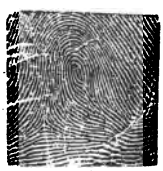
80

81

Loops approximating Standard II



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Central Pocket Loops—Standard III

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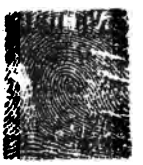
Central Pocket Loops—Standard III

90

Loops approximating Standard III

91

92



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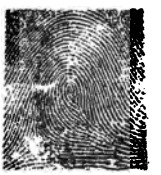

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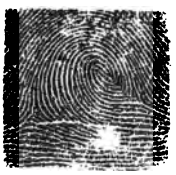
Central Pocket Loops—Standard IV



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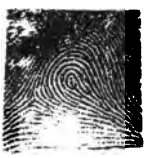

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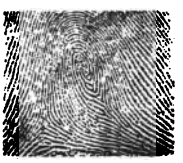

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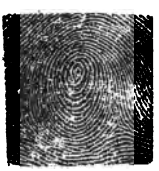
Whorls.



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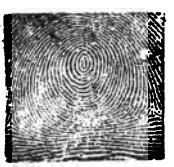

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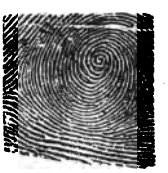

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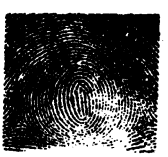

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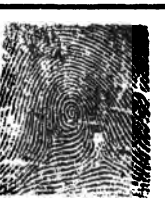

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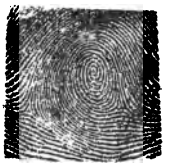
Whorls.

109

110



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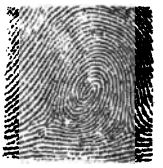

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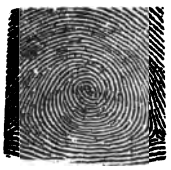

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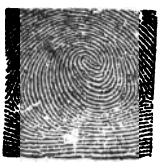

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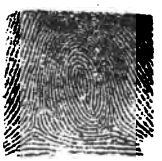

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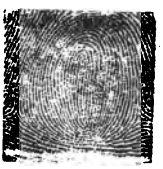

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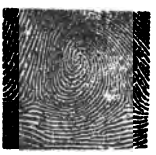

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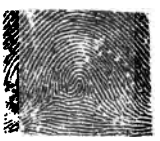

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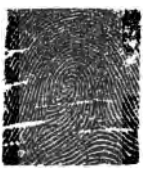

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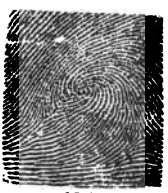

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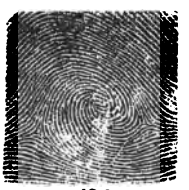


124

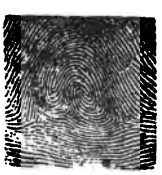
Compound Patterns.

125

126

127

128



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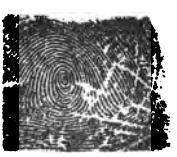

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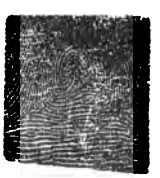


132

Tracing the Ridges.

Inside

133

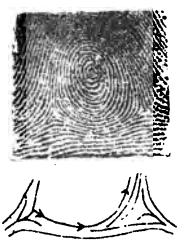
134

135

136

Meeting

137



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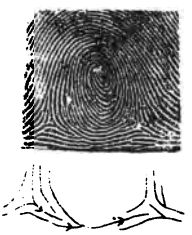

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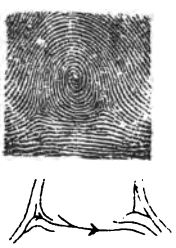

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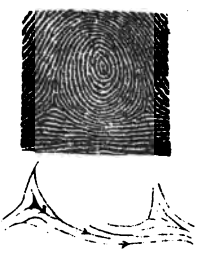

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Outside

145

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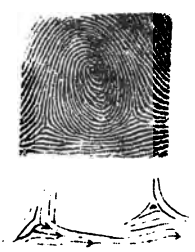

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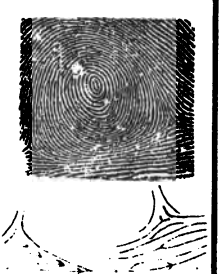

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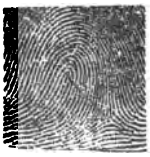
Counting the Ridges.

O. T.

I. T.

Counts 12

149



O. T.

I. T.

Counts 15

150

O. T.

I. T.

Counts 14

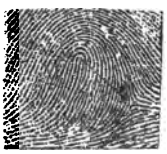
151

O. T.

I. T.

Counts 4

152



O. T.

I. T.

Counts 15

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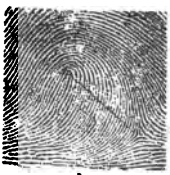


O. T.

I. T.

Counts 26

154

O. T.

I. T.

Counts 11

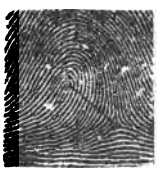
155

O. T.

I. T.

Counts 10

156



O. T.

I. T.

Counts 15

157

O. T.

I. T.

Counts 10

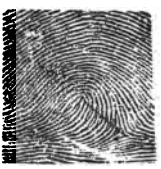
158

O. T.

I. T.

Counts 15

159



O. T.

I. T.

Counts 11

160

O. T.

I. T.

Counts 7

161

O. T.

I. T.

Counts 15

162

O. T.

I. T.

Counts 10

163

O. T.

I. T.

Counts 10

164

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